RECENT ADVANCES
IN SURGERY

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RECENT ADVANCES IN SURGERY

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With a Foreword by

Maj.-Gen. SIR HENEAGE OGILVIE

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in the gallery and they can at least [illegible] the expert but [illegible] the play going on below them. But when they are [illegible] their judgment becomes progressively clouded by their own personal experience and they must inevitably judge the work of others by the extent to which they correspond with their own.

To write of recent advances in surgery [illegible] insight is a task of the greatest difficulty. There are [illegible] and 200 monthly or quarterly journals in the English language alone, and about a quarter of them are devoted to surgical topics. There are fifty journals devoted entirely to surgery or the surgical specialties. There are at present twelve [illegible] tions that attempt to summarize the news [illegible]. In addition some 400 to 500 surgical textbooks [illegible] launched yearly. Through all this mass of literature the author must pick his way, attempting to winnow out the chaff and to keep only the seed that is likely to germinate.

Another difficulty that confronts the writer on recent general surgery is the revaluation of work that seemed at the time of its introduction to be sound and successful. To the surgeon looking for guidance it is as important to know of those advances that have failed to live up to their early promise as it is to be told the latest work from the laboratory. The last five years have seen many such reassessments. Pancreatico-duodenectomy has been made reasonably safe but its late results have proved so disappointing except in ampullary growths that a more simple short circuit is now preferred for the treatment of cancers arising in the head. Operations for prolapse of the intervertebral disc have not lived up to early expectation, and though the addition of fixation by intervertebral bone blocks may give better results, at present few cases are subjected to exploration till belts and physiotherapy have been given a prolonged trial. The surgery of hypertension has fallen even more rapidly into disfavour and operations on the sympathetic chain are now seldom performed except as a palliative for failing vision and intolerable headaches.

I have said enough to indicate the difficulties in deciding what are recent advances in surgery. My attempt to answer the question in 1928 was received kindly, and a second edition was called for so quickly that it involved no more work than a general revision of the chapters and the addition of two fresh ones on cancer and radium therapy. When I came to tackle a third edition I found that I had become more critical both of the writings of others and of my own. I had to read far more widely to form an opinion and I had less time to read. I worked hard, but by the time

The definition of surgery is even more difficult Surgery is the treatment of diseases or injuries by manual processes, and its greatest advance took place after Lister had showed the way to combat infection and allowed surgeons for the first time to repair remould and transplant as well as to incise and excise and to carry their enterprise into all regions of the body For thirty years they explored and invented But the advances in operative surgery were almost complete thirty years ago and further development has been in the nature of detailed improvement except for the growth of certain special branches which has been made possible by discoveries in fields other than those of operative method Surgical technique has improved no whit in the last quarter of a century It is true that in the first two decades of the twentieth century good technicians were as uncommon as bad ones are to day but the best operators of 1910 were every bit as skilful as the best of 1930 That the work being done to day is better in every way the operations being undertaken greater in scope and severity the operative mortality and the post operative morbidity infinitely less and the functional results of intervention better beyond computing is due to the development over the years of drugs apparatus and ancillary methods that have made the surgeon s task easier and safer to intravenous medication to improvements in resuscitation, particularly to the perfection of methods of transfusion of storing blood and of preparing blood substitutes to an appreciation of the problems of fluid and electrolyte balance to the use of intestinal decompression to the introduction of electro coagulation and of improved electrical and optical instruments to better materials for fixation ligature and suture to the discovery of the chemotherapeutic and antibiotic drugs to methods of preserving living tissues apart from the body above all to the great developments that have taken place in the science and art of anæsthesia

To survey this field adequately requires two things wide knowledge and an independent judgment and very few surgeons possess both of these attributes and none of them possesses them for very long They have a wide knowledge at the time when they themselves are preparing for a higher examination and for some time afterwards when they are helping to prepare others but as the years pass by they tend inevitably to confine their study to those aspects of surgery to which circumstances or their talents or interests lead them and their knowledge becomes deeper but less wide They have an independent judgment when as advanced students they have the understanding to assess without personal bias They stand

PREFACE

[illegible] Recent Advances [illegible] the author [illegible] the former plan [illegible] but at the [illegible] The latter plan [illegible] but will ensure that [illegible] perfection can be achieved.

In the construction of the fourth edition of Recent Advances [illegible] the latter plan has been adopted with [illegible] Having made the decision I sought the help of [illegible] contributors to the third edition, Sir [illegible] and Mr Douglas Northfield, and formed with them an [illegible] Committee, to which was added Mr J. Holm[illegible] Nell[illegible] [illegible] Mr Selwyn Taylor's advice was also sought. I offer my thanks for the assistance they gave so freely. To them also and to the other contributors to this book my thanks are due for their immediate response to my invitation to contribute and for the promptness with which each has carried out his task.

My thanks are also due to Dr [illegible] for proof reading, and to Miss Doreen Kemp for her untiring secretarial work and for the preparation of many of the illustrations.

Acknowledgments are recorded under the appropriate figures to those authors and publishers who furnished illustrations or who permitted their reproduction, and I wish here to thank them all for their generosity. I should like also to thank my publishers, Messrs J. & A. Churchill Ltd, for their patient and sympathetic co-operation.

Lastly, my grateful thanks go to Sir Heneage Ogilvie, the original author of "Recent Advances in Surgery," for writing the Foreword.

H. C. I.

I had finished a chapter it was already due for revision. In eight years I finished only four new chapters to my satisfaction and despite the constant encouragement and inexhaustible patience of Mr. [illegible] I was finally forced to abandon the task and hand over to my friend Harold Edwards.

It would be out of place for me to praise the admirable manner in which Mr. Edwards has accomplished his task, but I would say, as my interest in the book is that of a parent for his firstborn, that I am most grateful to him for the way in which he has brought it to successful maturity and established it in the fore of the standard works in surgery, and I wish him and his book all success.

HENEAGE OGILVIE

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PART I—GENERAL

CHAPTER I

WATER AND ELECTROLYTE METABOLISM

A W WILKINSON

The General Metabolic Disturbances after Injury

During the last ten years numerous attempts have been made to overcome the catabolism of body tissues especially of protein, which is such a prominent metabolic feature of the first week after operation These experiments have met with varying degrees of success However it is now widely accepted that the post traumatic catabolic phase ' of nutrition is part of the normal response to injury by a well nourished living body, and that this response cannot be much modified by any of the measures which have been tried including the prevention of starvation by maintenance of caloric intake and the provision of an abundant supply of whole or hydrolysed protein It has also become evident that the protein catabolism is only one aspect of a very complicated but entirely normal reaction which appears to provide the raw materials of the inflammatory response to injury and to infection

Apart from the circulatory and psychological disturbances the earliest change seems to be the mobilization of water and its associated potassium from uninjured cells This potassium is excreted in high concentration in the urine and thus probably renders water derived from the cells available for the maintenance of such essential purposes as insensible loss through the skin or in the expired air This loss of potassium lasts from about six or twelve hours until thirty six hours or more after injury After severe injury urinary output is always diminished and may cease entirely for twelve hours or more When urine formation restarts the daily output is usually reduced for the next week or so During this time there is reduction also in the quantities of sodium and of chloride which are excreted in the urine each day these reductions occur regardless of the quantities of sodium and chloride which are ingested or administered In well nourished subjects the urinary output of nitrogen rises sharply within about twenty four hours

able to believe that the extensive metabolic changes and alterations in the distribution of body water and ions may be controlled by adrenal hormones

The great variation in methods of post operative treatment in different surgical clinics and the similarity of the average results of these many methods indicate that in some respects the patient recovers in spite of the treatment It is usually only when some body constituent, such as water, sodium potassium or protein is grossly deficient or when fat is excessive, or when there is disease of important organs, such as the liver or kidneys, that the body is unable to produce the complex endocrinological and metabolic response to injury on which survival depends Because starvation and the restriction of drinking are so common after severe operations, knowledge of their effect on normal men helps us to understand the effects on surgical patients

In a temperate climate the daily water requirements can be divided into those for essential extrarenal purposes—insensible loss as vapour by diffusion through the skin and in the expired air—and renal requirements for urine formation Dubois (1927) estimated that the average insensible water loss was 0 5 gm water per kilogram body weight per hour or 840 ml per day for a 70 kg (11 stone) man a similar figure was obtained by Gamble (1946–47) This is the primary water requirement which must be satisfied regardless of other needs and abnormal losses Up to 200 ml of water per day may be lost in normal fæces but much larger quantities are lost in diarrhœa The daily volume of the urine depends primarily on the quantity of solutes resulting from metabolism which require excretion by the kidney this will vary with the nature and quantity of food consumed or the type of starvation and the metabolic state of the patient The volume of water required to carry away these solutes in turn depends on the concentrating capacity of the individual kidneys The minimum volume for healthy adults is between 500 and 600 ml per day Urine volumes greater than this are usually due to the consumption of water in excess of the minimal requirements The total daily basal requirement of water is thus about 1 500 ml It is a common clinical error not to make a daily allowance based on the actual body weight of the patient for insensible water loss Fortunately this is usually amply compensated by the generous ideas which prevail regarding the average daily volume of urine and thus of the necessary water intake

When a normal man is deprived of both water and food about 200 ml of water are obtained from the oxidation of body fat and protein but the remaining 1 300 ml must come from extracellular

after operation and remains greater than before operation for a period of from five to eight days this increase in nitrogen excretion does not occur in patients whose body protein content has been greatly reduced by previous under nutrition After about a week there is usually an increase in the daily urinary volume and a rise in the quantities of sodium and chloride which are excreted the daily urinary nitrogen excretion falls and there is generally a slow rise in potassium excretion By about the end of a fortnight after operation all these changes gradually pass off and urinary volume and composition return to normal

The post traumatic retention of sodium chloride and water occurs at a time when the formation of an inflammatory exudate requires the provision of a large volume of extracellular fluid the normal post operative renal conservation of sodium and water results in a measurable increase in extracellular fluid volume which lasts for about as long as does the inflammatory reaction Fox and Baer (1947) showed that in the injured animal sodium and water were transferred from uninjured to injured tissues the sodium content of which rose and potassium content fell each shift of cations being accompanied by appropriate quantities of water Similar large shifts of body fluids are now clinically recognized in thermal burns, in extensive injuries of limbs such as compound fractures and in peritonitis ileus and from intestinal fistulæ The provision of very large volumes of inflammatory exudate from the existing fluids and tissues of the injured individual s own body causes a severe disturb ance of internal equilibrium An inflammatory reaction to injury or irritation is found in most forms of living tissues and is a fundamental requirement for survival Therefore it is hardly surprising that the means of reducing or modifying the intensity of the reaction has not yet been discovered However it is known that previous under nutrition will reduce the output of nitrogen after injury by diminish ing the quantity of protein tissue available for catabolism After operation the prolongation of dietary restriction especially in regard to calories will increase the period during which protein tissue is broken down as will also infection and wound disruption The renal conservation of sodium and water occurs in spite of an abundant provision of these substances, and may give rise to the retention of large quantities of sodium and water

Recent work has linked these changes in bodily composition and urinary constituents with the sudden reduction in the number of circulating eosinophils which may be associated with severe surgical injury and with the changes in the urinary output of various end products of adrenal cortical hormone metabolism It seems reason

able to believe that the extensive metabolic changes and alterations in the distribution of body water and ions may be controlled by adrenal hormones

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When a normal man is deprived of both water and food about 200 ml of water are obtained from the oxidation of body fat and protein but the remaining 1,300 ml must come from extracellular

and intracellular fluid with an accompanying loss of sodium and potassium Potassium is lost at a fairly constant rate, but after three to five days sodium is conserved by the kidneys so as to maintain the volume of extracellular fluid and all the water is then obtained from the cells after injury sodium is usually retained from the first day Dehydration by thirsting probably causes death when between 30 and 40 per cent of body water has been lost this is equivalent to 15 to 17 litres in a 70 kg (11 stone) man, which at 1 300 ml per day will be lost in ten to thirteen days

When food is withheld but ample water is provided fat and protein are still catabolized to provide calories but body water in addition to that in the catabolized tissue no longer need be lost If in addition 100 gm glucose are provided each day, the catabolism of protein tissue is reduced ketosis is prevented and the quantity of solutes requiring excretion in the urine is reduced and the minimum *urinary water requirements are thereby halved No more than* 100 gm glucose need be provided because this quantity reduces protein catabolism to the minimum rate of 40 gm per day The provision of 100 gm glucose per day as 2 litres of 5 per cent glucose solution will provide a large surplus of water as well as optimal *metabolic conditions for survival in a fasting normal person*

After severe accidental or surgical injury most patients lose their appetite for food for up to four days but there is usually intense thirst throughout this period This thirst is not relieved by the intravenous administration of glucose solution or isotonic *saline and is possibly due to the intracellular* dehydration resulting from the mobilization of intracellular water and its associated potassium During the first three or four days after operations on the alimentary tract the free consumption of water is undesirable because absorption and intestinal motility are impaired and the fluid *consumed accumulates and leads to distension* of the stomach When drinking is allowed but accumulation of the water is prevented by continuous or intermittent gastric aspiration gastric and intestinal secretions are removed with the water or other fluid which has been drunk If it is necessary to continue gastric aspiration for more than forty eight hours this additional loss of electrolyte may accelerate or precipitate potassium deficiency in patients who have already been depleted of this ion by repeated vomiting before operation Thirst is best relieved by washing out the mouth frequently with cold water and after partial gastrectomy drinking may safely be forbidden for twenty four to forty eight hours

The intravenous administration of glucose solutio bably

unnecessary unless drinking is impossible for more than forty eight hours after operation Because renal conservation of sodium is so efficient after injury, in the absence of abnormal losses there is no real need for sodium intake until the end of the first week after operation when it will be adequately provided by the consumption of food Saline should not be administered even when gastric aspiration is necessary, *unless the quantities of fluid removed are very large or cause reduction of blood volume* Severe water and sodium depletion can usually be corrected before operation is undertaken The correction of potassium deficiency is dealt with later

Water Intoxication

Immediately after the war of 1939–45 there was a marked increase in the frequency with which the intravenous administration of various fluids especially saline was employed This has now given place to a more conservative and critical use of these fluids and œdema caused by excessive infusions of saline is much less common This tendency to restrict the use of saline has sometimes led to the employment of larger quantities of glucose solution which are believed to be comparatively innocuous However, in association with sodium deficiency, or when diuresis is delayed during the first week after injury or operation in patients aged more than fifty years or when renal function is impaired, the rapid injection of a large volume of glucose solution can lead to a state of water intoxication

The danger of pushing fluids is too little recognized and severe clinical disturbances have been recorded after both rectal and oral administration of water There may be stupor confusion, amnesia and coma *there are no constant motor neurological* effects but twitchings of the face and limbs are common and convulsions of epileptiform type may occur The disturbance is not due simply to raised intracranial pressure but to a rapid dilution of the extracellular sodium which upsets the normal equilibria at the cell membrane and leads to a transfer of water into the cells causing hypotonicity of the intracellular fluid and disturbance of cell function Œdema is not invariably present because rapid administration rather than a large excess volume of water is the important factor and the water is widely distributed in the cells and in their environment This disturbance is treated by the stoppage of further administration of water which may be followed by a slow spontaneous recovery by excretion of the retained water In severe cases recovery may be accelerated by the slow intravenous

injection of hypertonic (2–5 per cent) saline until symptoms are relieved (Zimmermann and Wangensteen, 1952 Baskins *et al*, 1952)

Potassium Metabolism

Until about 1945 clinical interest in potassium metabolism was limited to its possible toxic action in the late and terminal stages of severe shock caused by injuries such as burns, and the existence of low serum concentrations in Addison s disease and Cushing s syndrome and in rare cases of alkalosis or infantile diarrhœa The investigations of Darrow (1945) and his associates on the treatment of infants with diarrhœa showed that in this condition there was a migration of potassium out of the cells which could be reversed by the administration of potassium salts Subsequently the application of their work to other diseases showed that potassium deficiency was a good deal more common in surgical patients than had been previously suspected (Randall *et al* 1949 Evans 1950), and it is now evident that mild degrees of potassium deficiency may be responsible for a large amount of indefinite invalidism and sluggish convalescence

In the body of a 70 kg adult there are about 150 gm of potassium 97 per cent of which is situated in the cells in a concentration of about 150 mEq per litre the remaining 3 per cent being in the extracellular fluid in a concentration of only 4 0 to 5 5 mEq per litre It is probable that about two thirds of intracellular potassium is loosely bound in a protein complex and does not readily change its situation but the remainder together with the extracellular potassium moves freely between the interior of the cells and their surrounding medium The old belief that the cell membrane is impermeable to sodium and potassium must now be abandoned because recent work by Cooke *et al* (1952) has proved that in severe alkalosis associated with potassium deficiency large quantities of potassium may be transferred out of the cells and be replaced by sodium and hydrogen ions During cellular catabolism in starvation and after severe injury potassium is lost from the cells whereas during cellular anabolism in refeeding after starvation potassium moves into the cells a striking example of rapid potassium uptake by the cells from the extracellular fluid occurs during the treatment of diabetic acidosis when it may be so rapid as to depress the extra cellular potassium concentration well below the normal range

The normal daily intake of potassium is about 2–3 gm (75–100 mEq) between 2 and 5 gm are secreted into and reabsorbed from the alimentary tract and 2–3 gm are excreted into the urine

Thus intake is balanced by output in the urine and although in health the body content of potassium changes little, there are large daily movements and exchanges of potassium in the body for the normal intake and output are each rather larger than the whole quantity of potassium in the extracellular fluid The maintenance of a normal quantity of potassium in the body depends on a steady intake because there does not appear to be a renal conservation of potassium in depletion such as exists in the case of sodium During starvation when calories are derived from the catabolism of fixed tissue which contains potassium, survival depends on this ability to excrete potassium in the urine , if this were not possible, death would rapidly ensue from the accumulation of potassium in the extracellular fluid resulting in elevation of the potassium concentration Berliner *et al* (1950) believe that urinary potassium excretion is largely independent of both plasma concentration and the rate of glomerular filtration

The daily loss of 2–3 gm potassium in the urine continues even when intake of potassium is reduced or stopped, or when there are abnormal losses of potassium in vomitus, gastric aspirations, diarrhœa or discharges from intestinal fistulæ Since the concentration of potassium in the intestinal secretions exceeds that of the extracellular fluid potassium must be mobilized from the cells to replace that lost in these secretions and in the urine Despite the daily loss of 5 or 6 gm potassium the plasma concentration remains steady until the intracellular deficiency becomes very large Darrow (1945) estimated that 25 per cent or more of the initial content of about 150 gm might be lost in this way The replacement of losses of this magnitude may be difficult and may take up to two weeks to accomplish

The large losses of potassium sustained by repeated vomiting or by prolonged gastric aspiration have been studied clinically and experimentally by Webster *et al* (1950) They believe that such potassium losses which appear to diminish intestinal motility may exaggerate so called paralytic ileus In addition there appears to be an increase in the volume of gastric secretion the potassium content of which is undiminished although the sodium and chloride concentration may fall As others (notably Gamble 1946–47) have pointed out the intravenous administration of glucose solutions or isotonic saline also increases the urinary excretion of potassium Potassium deficits and intracellular hydration can be restored only if potassium salts are administered

The diagnosis of potassium deficiency is difficult because of the predominantly intracellular situation of body potassium and the

lack of any clinically convenient means of measuring the total quantity of potassium in the body With the aid of the flame photometer the rapid measurement of the concentration of potassium in biological fluids is now possible but the routine application of such measurements is still uncommon in patients subjected to gastric aspiration or with losses of fluid caused by diarrhœa or intestinal fistula The earliest signs are probably drowsiness poor appetite muscular weakness and low grade ileus In the fully established state, drowsiness is intense and muscular weakness is very marked the patient lying slumped in bed incapable of keeping his eyes open or of speaking more than a few words at a time There may be urinary incontinence and difficulty in swallowing the blood pressure and pulse rate are low and the skin looks dirty The serum potassium concentration is not invariably reduced even in advanced potassium deficiency because the extracellular potassium is only a very small part of the total body potassium and is the result of the combined effects of external loss in the urine and in lost body fluids on the one hand and of the mobilization of cellular potassium on the other hand apart from this balance variations in extracellular fluid volume alter the serum potassium concentration and reduction in extracellular fluid which is particularly liable to follow the rapid loss of gastro intestinal secretions raises serum potassium concentration even when total extracellular potassium is reduced Measurement of the hæmatocrit gives valuable assistance in the interpretation of the serum concentrations of sodium bicarbonate and chloride as well as of potassium After extracellular fluid volume has been increased by the intravenous administration of saline or even of a fluid which contains potassium salts it is not uncommon to find that the serum potassium concentration has fallen because of dilution of the small quantity of extracellular potassium by the administered fluid and also because of an increased rate of excretion of potassium in the urine

Potassium deficiency may lead to abnormalities of the electrocardiographic tracing but these changes are neither invariably present nor always related directly to the severity or duration of the potassium depletion and cannot be regarded as more than confirmatory evidence of depletion the E.C.G. is of more value in diagnosing potassium excess than deficiency Because severe potassium deficiency may exist when both the serum potassium concentration and the E C G tracing are normal it seems wise to rely for diagnosis chiefly on clinical suspicion aroused by unusual drowsiness and muscular weakness in a patient who has a known

history of prolonged loss of body fluids by vomiting, aspiration or from a fistula

Mild potassium deficits result from all types of injury and inflammation and can be satisfactorily replaced by potassium consumed in the ordinary diet during convalescence, the wisdom of our ancestors in prescribing fruits and fruit juices beef and chicken tea broth and thin soups for the convalescent patient has been endorsed by analysis of these invalid foods which show them to contain relatively large quantities of potassium salts Provided that rapid replacement is not essential more severe deficiencies can be replaced by the oral administration of potassium chloride in doses of 1 gm (13 mEq K+) upwards to a total of 12 gm (156 mEq K+) per day When there is coma or extreme drowsiness with anorexia in an unco operative patient parenteral administration of potassium salts becomes necessary at least in the initial stage of treatment Before an intravenous infusion of fluid containing potassium is started, a urinary output at the rate of at least 500 ml per twenty four hours must be ensured if necessary by the infusion of glucose solution in order to allow for the excretion of any excess of potassium which may be inadvertently administered, this avoids the extracellular accumulation of potassium leading to serum concentrations exceeding 7 mEq per litre which cause severe conduction disturbances of the cardiac muscle and may lead to cardiac arrest It is always wise to record the pulse rate every hour during potassium infusions and if it slows unduly to replace the potassium solution with glucose solution Potassium salts should not be administered during the first forty eight hours after injury or after the onset of an inflammatory reaction to injury because there normally is a large diuresis of potassium during this period or in the presence of anuria, marked oliguria or other severe disturbances of renal function

Potassium deficiency may be accompanied by alkalosis when the cause is prolonged vomiting or gastric aspiration, or by acidosis when it is due to diarrhœa The anion to be administered with the potassium should be varied according to the accompanying disturbance In potassium deficiency accompanied by alkalosis potassium chloride is usually employed the usual method being to add 20 ml of a concentrated solution (10 per cent) of potassium chloride to each 500 ml isotonic glucose solution thus providing 4 gm potassium chloride (52 mEq K+) per litre Because in potassium deficiency with alkalosis there is a shift of sodium into the cells which renders the alkalosis resistant to saline therapy alone it is essential that potassium chloride be administered first before any sodium chloride is given if improvement is to be achieved

Later when some potassium has been replaced, the concentrated potassium chloride may be mixed with isotonic saline instead of glucose For the correction of potassium deficiency combined with acidosis Darrow s K lactate solution containing 2 7 gm potassium chloride (35 mEq K^+), 4 0 gm sodium chloride and 52 gm sodium lactate per litre is best The rate of intravenous administration of solutions containing potassium should not exceed 20 mEq potassium per hour and considerably less than this rate is usually advised Darrow has estimated that up to 3 5 mEq potassium per kilogram body weight (245 mEq potassium per 70 kg (11 stone) man) can be given per day

Plasma Substitutes

Prior to 1940 shock due to plasma loss such as occurs after burning and scalding was usually treated by the rapid infusion of solutions of gum acacia in saline Some adverse effects associated with these infusions were reported and were ascribed to the gum acacia but the general experience was that provided reliable preparations were used gum acacia solutions were safe and produced satisfactory and lasting improvement in shocked patients Following the establishment of blood banks human plasma became freely available and the use of gum acacia declined Since the war because of the risk of homologous serum jaundice and of reactions which occurred with a widely variable frequency during and after plasma infusions there has been a tendency to employ other fluids in the treatment of shock due to plasma loss The plasma substitutes at present available are gum acacia dextran and polyvinyl pyrrolidone The use of plasma substitutes is increasing and some discussion of their ideal properties and behaviour in the body seems timely

A plasma substitute must not be toxic pyrogenic or antigenic it must be stable for long periods at wide ranges of temperature easily sterilized and capable of being cheaply made in a constant *form Its viscosity and osmotic* pressure should resemble those of blood and although initially enough must remain within the blood stream to produce a lasting increase in blood volume ultimately the substance should be completely metabolized or excreted The retention of injected material within the blood vessels depends largely on the molecular weight of the substance employed All the preparations which are at present used as plasma substitutes contain mixtures of molecules of different weights and the behaviour of a particular preparation naturally depends on the relative proportion of molecules of different molecular weights which it contains For

example, material of a molecular weight less than about 70 000 will be rapidly excreted in the urine and the effect of such material on blood volume will be short solutions which contain a large proportion of such material of small molecular weight will cause a marked diuresis after injection There is reason to believe that material having a molecular weight between 70,000 and 130,000 is probably largely lost from permeable capillaries in the rest of the body so that only that portion of injected material the molecular weight of which exceeds 130,000 remains for any length of time within the vessels and will by reason of its water holding capacity, be capable of maintaining an increase in blood volume This fraction will be retained in the circulation until it is either metabolized, deposited in the cells of the reticulo endothelial system or excreted after partial breakdown Material with a molecular weight exceeding 250,000 causes undesirable aggregation of red cells and increase in the sedimentation rate and viscosity of the blood An ideal preparation should consist of a large proportion of material of molecular weight between 130,000 and 200,000 and as little as possible above 250 000 and below 70 000, and that between 70 000 and 130 000 should be as small as economically possible

Crude preparations of the substances available contain a mixture of particles of molecular weight ranging from a few thousand to several million The large molecules must be hydrolysed or otherwise broken down and the larger and smaller molecules must then be removed by some process of fractionation so as to leave a mixture the majority of which will be retained in the vessels for a sufficiently long time after injection The difficulties associated with large scale degradation and fractionation vary with different materials and are important factors in the economic production of a product with the desirable narrow range of molecular weights

Gum acacia has been extensively used as a 6 per cent solution in 0 9 per cent saline since it was introduced into clinical use by Bayliss in 1917 It is obtained from the natural gum of the acacia thorn and has other wide applications in industry Provided that reliable preparations are used reactions are rare Like polyvinyl pyrrolidone and dextran its larger molecules are deposited in the reticulo endothelial system but Bollman (1951) has shown that in dogs liver function was unimpaired ten years after the injection of very large quantities of acacia Amberson (1937) reported that 61 per cent was retained in the circulation for twenty four hours after injection

Polyvinyl pyrrolidone (P V P) is a synthetic water soluble polymer of acetylene which is usually employed as a 3 5 per cent solution

and is also known as periston kollidon or plasmosan P V P is not metabolized in the body but up to 75 per cent or more of the injected material has been recovered from the urine and as much as 50 per cent may be excreted during the first twenty four hours after injection Clinical observations suggest that P V P is not as effective as either gum acacia or dextran in the treatment of low blood volume states

Dextran is a long chain polysaccharide resulting from the bacterial polymerization of glucose molecules It was first prepared and used as a plasma substitute in Sweden, and since 1946 has been widely used in other countries (Bohmansson *et al* 1946 , Thorsen 1949 Bull *et al* 1949) Improvements in the method of fractionation have resulted in the production of solutions of which only 10 per cent is lost in the urine in the first twenty four hours after injection and 60 per cent remains in circulation for a day or longer there is less wastage of the dose in the urine and tissue fluid and a smaller volume is required to produce a particular effect This preparation represents an important advance towards the achievement of a theoretical ideal plasma substitute Dextran like all other sub stances of large molecular size may be deposited in the reticulo endothelial system but this does not appear to cause ill effects There have been a number of reports of anaphylactic reactions following the injection of dextran of both Swedish and British manu facture These reactions are more common when dextran is injected into normal control subjects than when it is used as part of the treatment of a shocked patient Thorsen (1949) found an incidence in Sweden of only 0 8 per cent compared with 8 2 per cent after blood transfusion The high incidence of reactions in the United States of America was ascribed to the commoner occurrence of certain types of pneumococcal antibodies there It is possible that in normal subjects the reactions associated with large infusions of dextran in normal subjects is due to overfilling of the circulation rather than to antigenic reactions

Each of these three preparations (gum acacia P V P and dextran) by causing aggregation of red cells may interfere with blood grouping reactions and extra care is required in assessing results This can be avoided if a blood sample is withdrawn before the plasma substitute is injected

The best results are obtained when plasma substitutes are injected rapidly for example the first 500 ml in ten or fifteen minutes and the next 500 ml in twenty minutes and even faster injection may be necessary when severe blood or plasma loss has occurred Slow maintenance infusions are not advisable The principal

indications for the employment of plasma substitutes are plasma loss due to burning or scalding, when there is delay in obtaining or matching blood for transfusion, instead of blood when the volume required does not exceed 1 litre, and as a supplement to blood when in spite of full replacement of blood loss the blood pressure has not been fully restored.

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paved the way to a new era of chemotherapy In addition to the modern range of sulphonamides a group of drugs showing antituberculosis activity the sulphones have been developed

A recent addition to the antituberculous drugs are the thiosemicarbazones para aminosalicylic acid and iso nicotinic acid derivates

Sulphonamides

The wide range of modern sulphonamides has been obtained by the substitution of different chemical groups about the sulphonamide nucleus On theoretical grounds it is unlikely that any sulphonamide will surpass sulphathiazole and sulphadiazine in antibacterial activity further improvements have been concerned with the reduction of toxicity—nausea headache drug fever skin eruptions and damage to blood forming organs—and with changes affecting the speed of absorption and excretion and the solubility of the acetylated or conjugated compounds excreted in the urine Sulphadimidine (sulphamezathine sulphamethazine) is more rapidly absorbed than sulphadiazine to which it is closely allied and more slowly excreted than sulphathiazole thus adequate blood concentrations can be maintained with doses given at six hourly intervals It is however usually given in the same dosage as that for sulphathiazole and sulphadiazine namely for an adult an initial dose of 2–4 gm followed by 1 gm four hourly for two days 1 gm six hourly for two days and 1 gm eight hourly for two days

Another sulphadiazine derivative is sulphamerazine which is even more slowly excreted with this drug a high blood level can be achieved with smaller and less frequent doses than with any other sulphonamide Although sulphamerazine and sulphadiazine may be used alone in the treatment of acute infections, this is not recommended because of the danger of renal obstruction they are, however very suitable for combining with other sulphonamides in mixtures such as Sulphatriad which contains approximately equal parts of sulphathiazole sulphadiazine and sulphamerazine The danger of renal damage is thereby greatly reduced because whereas the antibacterial activity of the various sulphonamides in the mixture is additive the solubilities of the compounds excreted in the urine are independent of one another depending solely upon the concentration of each drug in the urine Sulphadimidine, its isomer sulphasomidine (' Elkosin) and sulphafurazole (' Gantrisin) which are much more soluble than sulphadiazine or sulphamerazine are almost entirely free from the risk of crystallization in the urinary tract they are also three of the least toxic sulphonamides Since

CHAPTER II

ANTIBACTERIAL THERAPY

A C CUNLIFFE

THE progress of a bacterial infection may be influenced in three ways

(a) by measures directed towards the maintenance or improvement of the natural non specific defensive mechanisms of the body ,

(b) by immunological procedures which provide or stimulate the production of specific antibodies and

(c) by the administration of antibacterial drugs

Within recent years there have been no immunological advances comparable in importance to the surgeon with the rapid developments in chemotherapy this chapter therefore is confined to the discussion of some of the more important antibacterial substances and their uses

The majority of substances with a disinfectant action belong to the class of general protoplasmic poisons and are as likely to damage the host s tissues as to kill parasites infecting the body For use in the treatment of infections in the living animal a substance must have a selective action on the parasite and be relatively non toxic to the host s tissues Such antibacterial substances belong to two classes synthetic drugs and natural substances from other microbes—antibiotics It should be pointed out that since several of the antibiotics have been synthesized chloramphenicol in particular being manufactured by a synthetic process this distinction is somewhat artificial Further it should be noted that the term antibiotic is applied without reference to toxicity and that only a small number of those discovered are therapeutic agents

CHEMOTHERAPEUTIC AGENTS

The brilliant successes of chemotherapy which followed Ehrlich s synthesis in the early years of the century of arsphenamine and other organic arsenicals were mainly confined to various spirochætal and protozoal diseases The greatest hope in the treatment of bacterial disease appeared to lie in the 'magic bullets' of the antibodies In 1935, however Domagk s discovery of prontosil

thio semicarbazones have been investigated, one of these, amithiozone has been studied in human tuberculosis but it appears to have no greater effect than para aminosalicylic acid (P A S) which is very much less toxic P A S does not compare with streptomycin or isoniazid in its antibacterial effect but it can be administered for very long periods with little risk of the emergence of drug resistant strains Toxic manifestations which are mainly gastro intestinal, are relatively rare Its most valuable *role* is that of an adjuvant to streptomycin therapy

Many isomers and derivatives of nicotinic acid have powerful effect on the tubercle bacillus *in vitro* and *in vivo*, the effectiveness of isonicotinic acid hydrazide (Isoniazid) has been confirmed by clinical trial but its therapeutic effect is short lived, and its later ineffectiveness is associated with the development of drug resistance This resistance is however, greatly delayed if streptomycin and/or P A S is given at the same time

ANTIBIOTICS

The word antibiosis" was first used by Vuillemin in 1899 to describe the process whereby "one creature destroys the life of another in order to sustain its own Ten years later it was applied to microbial antagonism by Marshall Ward In 1942 Waksman introduced the term 'antibiotic' for the chemical substances of microbial origin that possess antimicrobial activity Innumerable examples of bacterial antagonism have been recorded since the earliest days of bacteriology it may now, however, seem surprising to find that from the first the possibility of therapeutic application was appreciated For example in 1887 Pasteur and Joubert described the destruction of anthrax bacilli by cultures of common bacteria and concluded these facts perhaps justify the highest hopes for therapeutics '

The first antibiotic was introduced to medicine by Emmerich and Low in 1899 this was an extract from cultures of *Ps pyocyanea* known as pyocyanase which was bactericidal to many bacteria including *B anthracis Str pyogenes* and *Staph aureus* Pyocyanase was used sporadically during the next thirty years in the treatment of a variety of human infections both topically and parenterally but its use became less frequent largely because different preparations varied greatly in activity and in toxicity Many other antibiotics were also described during this time but none was comparable in importance with penicillin which was discovered by Fleming in 1928 Impressed by its combination of high antibacterial activity

nearly all the sulphonamides and their conjugated forms are more soluble in alkaline conditions it is important in addition to ensuring an adequate urinary output to administer alkalis. The solubility of sulphasomidine and sulphafurazole however, is such that given a satisfactory urinary output alkalis are unnecessary. "Urolucosil" is another highly soluble sulphonamide of low toxicity which has been used for many years in Denmark. It is said to give a satisfactory bacteriostatic urinary concentration when doses of 0.1–0.2 gm are given five times a day. Not only is the maintenance of an alkaline urine unnecessary but a reduced fluid intake is said to be advantageous. Urolucosil may prove of particular value when long continued treatment is necessary.

Owing to their poor solubility in aqueous solutions the sulphonamides cannot be given parenterally except in the form of their sodium salts which being highly alkaline, are liable to give rise to venous thrombosis or tissue necrosis at the site of injection. Sulphacetamide (Albucid) is an exception; its sodium salt which is neutral is relatively non irritant to the tissues and can be safely introduced in the eye or paranasal sinuses.

Of widespread use in abdominal surgery are the poorly absorbed sulphonamides sulphaguanidine succinylsulphathiazole and phthalylsulphathiazole which are used for their local bacteriostatic effect in the lumen of the intestine. Of these, sulphaguanidine has the lowest therapeutic activity and is also most liable to give toxic reactions since as much as 30 to 60 per cent of this drug is absorbed; except in cases of severe ulceration of the intestine not more than about 5 per cent of the two sulphathiazole derivatives is absorbed. The total numbers of bacteria in the gut, in particular the coliform bacilli, are very greatly reduced but it is extremely doubtful if sterility is ever achieved. Succinylsulphathiazole has the occasional disadvantage of producing a semi solid stool; phthalylsulphathiazole on the other hand does not change the character of the stool and is reported to have two to four times the antibacterial activity of the former. The usual dosage is 10 to 12 gm per diem of succinylsulphathiazole and 3 to 12 gm of the phthalyl derivative.

Various Synthetic Antituberculous Drugs

The sulphones, derivatives of diamino diphenylsulphone are of historic interest in that they were the first drugs shown to have a therapeutic effect on experimental tuberculosis infections. Their toxicity however prevented their use in human tuberculosis but they have proved valuable in the treatment of leprosy. Various

preparations are amorphous and yellow or brown When penicillin is stored in the dry state potency is maintained unaltered for many years at room temperature In aqueous solutions on the other hand, it is relatively unstable, being rapidly hydrolysed in both acid and alkaline conditions and even when buffered and kept in a refrigerator is stable only for a few weeks

Systemic Administration

Benzylpenicillin is highly soluble and aqueous solutions are very rapidly absorbed from the tissues, the blood concentration reaching its peak within fifteen minutes of intramuscular injection providing the dose is not very large The reason why comparatively enormous doses have to be given therapeutically is that penicillin leaves the body as fast as it reaches the kidneys thus, this sharp rise of blood level is followed by a fall which at first is almost as steep, then progressively less In total anuria it has been estimated that an effective blood level could be achieved with a dose of only 350 units Caronamide and various other substances which interfere with excretion of penicillin have been used to obtain higher and more prolonged blood concentrations but they are not without danger since the effective dose is close to the toxic one Since the speed of excretion depends on blood concentration, it follows that the duration of effect is by no means directly proportional to the dose doubling the dose only prolongs the effect by about one third Thus, whereas penicillin is detectable in the blood for two and a half hours after an intramuscular dose of 25 000 units it is detectable for only about three hours after 50 000 units five hours after 250 000 units, and seven hours after 500 000 units Since about 60 per cent is excreted by the kidneys in an active form concentrations in the region of 100 units per ml are found in the urine after a dosage of 250 000 units a day

With substances such as sulphonamides and aureomycin whose action is mainly bacteriostatic it is essential to maintain an inhibitory concentration until the body s defence mechanisms have dealt with the infection since bacteria will resume multiplication as soon as the concentration falls Penicillin on the other hand, though in low concentrations mainly bacteriostatic, in slightly higher concentrations is actively bactericidal Further, it differs from most other bactericidal substances in that the speed of killing does not increase indefinitely with the concentration the optimal concentration for a sensitive organism such as a staphylococcus is quite low—about 0 1 unit per ml In these conditions 99 per cent or more of exposed bacteria may be killed within a few hours A

with low toxicity for leucocytes, Fleming suggested its use in the treatment of human infections, but his attempts to test this were unsuccessful owing to the instability and low potency of the penicillin preparations The discovery of tyrothricin by Dubos in 1929 is important even though it is too toxic for systemic administration because the extensive investigations which led to the separation of the active substance into two crystalline polypeptides gramicidin and tyrocidine represented a great advance in the study of antibiotics

The modern antibiotic era really started in 1940 when the success of Florey s team at Oxford in preparing penicillin in a potent and stable form made clinical trials possible The demonstration that penicillin was substantially non toxic to animal tissues and a powerful chemotherapeutic agent led to an outburst of research all over the world Hundreds of antibiotics old and new, have since been investigated So far few approach and none exceed penicillin with regard to the ratio of potency to toxicity but whereas the activity of penicillin is largely limited to the cocci and gram positive rods, many of the newer antibiotics (the so called broad spectrum antibiotics) affect a very much wider range of organisms including gram negative bacilli the rickettsia and some of the larger viruses

Streptomycin was isolated from *Streptomyces griseus* in 1944 by Waksman and his collaborators in the course of an intensive search amongst soil organisms for an antibiotic active against gram negative bacteria Chloramphenicol in 1947 aureomycin in 1948, neomycin in 1949 and terramycin and viomycin in 1950 were also isolated in America from species of Streptomyces Also prolific in antibiotics is the genus Bacillus bacitracin and polymyxin are products of *B subtilis* and *B polymyxa* species respectively

PENICILLIN

Penicillin is the name given to the sodium potassium or calcium salts of the antimicrobial organic acids that are produced by *Penicillium notatum* At least five penicillins of differing chemical composition are recognized of these benzylpenicillin (penicillin II or G) is the most commonly manufactured for medical use Penicillin O is available in the U S A and said to be useful for the treatment of patients sensitive to penicillin G with the increasing number of available chemotherapeutic agents however an antibiotic entirely unrelated to penicillin would seem to be a safer choice in these conditions

Pure benzylpenicillin is a white crystalline powder less pure

some wounds and in certain experimental abscesses but it has yet to be proved this is true of an area of inflammation without tissue breakdown The experimental work of Eagle has failed to show evidence of it

Slowly Absorbed Preparations

The earliest preparation used to delay absorption was a suspension of calcium penicillin in an oily base containing beeswax The beeswax however, which was essential for the delaying effect, tended to give rise to severe local reactions The use of this type of preparation has now been almost entirely superseded by aqueous or oily suspensions of the relatively insoluble procaine penicillin which is a compound of benzylpenicillin and procaine having an antibacterial activity equivalent to that of penicillin itself The rate of absorption of procaine penicillin varies considerably with its method of manufacture, depending upon the shape and size of the crystals hence one of the manufacturers difficulties is the production of crystals large enough to dissolve slowly and compact enough to pass through a small needle The usual dose is 300,000 units After an intramuscular injection of this dose of a good procaine penicillin in arachis oil the blood level rises to a maximum of 1 unit per ml in four hours and then falls very slowly so that a detectable amount is present after twenty four hours With preparations containing aluminium stearate absorption is still further delayed the blood concentration never reaches as high a level but may still be bacteriostatic after two days After a single dose of 2 000 000 units of one of these preparations a bacteriostatic level is maintained for six to seven days in bed patients and usually for five days in ambulant persons An interesting addition to the so called repository preparations is N N′ dibenzylethylenediamine penicillin ('Penidural or Benzethacil") Fletcher and Knappett (1953) found that after an intramuscular injection of 600,000 units of this preparation penicillin was detectable in the blood of all subjects after three days of the majority after fourteen days and of a few even after twenty eight days but during most of this time the blood concentrations were very low It seems to be generally true that prolonged action can only be achieved at the expense of low and often intermittent blood levels

Oral Route

Penicillin is destroyed by acid in the stomach, by bacterial enzymes in the large intestine and in a way imperfectly understood, in the small intestine There is great individual variation in the

few of Bigger's 'persisters' will always remain unkilled and since penicillin acts only on multiplying bacteria, it is held by many that intermittent treatment is advantageous in that it allows these persisters to begin multiplying during lapses in treatment and thus to become susceptible to further doses of penicillin

On the other hand many experts led by Eagle believe in the maintenance of a bactericidal concentration in the tissues throughout treatment Eagle Fleischman and Levy (1953) have added evidence in support of this view as the result of treating groups of mice with experimental streptococcal infections by a number of different penicillin *régimes*, varying both the dose and the intervals between doses recovery was quicker and more economical in penicillin when penicillin was given three hourly than when the interval between doses was longer Although arguments from mice to men must be made with caution it is probable that in this case they would be valid for there is a considerable amount of supporting clinical experience—for example in the number of patients whose infections respond to three or four hourly injections in hospital, after the previous failure of outpatient treatment with large doses of penicillin given once or twice daily

There is on the other hand abundant clinical evidence that in the treatment of many infections the need of a continuous bactericidal concentration is unnecessary Eagle and Musselman (1949) have shown that the time required for surviving bacteria to resume growth after the disappearance of penicillin from the tissues may vary from one to four hours The following intervals which are based on consideration of this factor are generally considered suitable between different doses for patients in whom it is desirable that the drug should exert a full and uninterrupted effect

Doses of Penicillin in Aqueous Solution given intramuscularly or subcutaneously	Interval
25 000 units	3 hours
50 000 units	4 hours
100 000 units	6 hours
250 000 units	8 hours
500,000 units	12 hours

Advocates of widely spaced doses of penicillin often contend that a large dose of aqueous penicillin exerts a much more prolonged effect than the rate of its elimination from the blood would suggest the high initial blood concentration is said to facilitate diffusion into foci of infection where penicillin remains long after the blood has been cleared of it It is true that penicillin persists in the exudate of

some wounds and in certain experimental abscesses but it has yet to be proved this is true of an area of inflammation without tissue breakdown. The experimental work of Eagle has failed to show evidence of it.

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mount absorbed in general five to ten times as much aqueous penicillin G must be given by mouth as intramuscularly in order to achieve the same effect It is best given on an empty stomach but even when large doses are administered with antacids about 5 per cent of adults fail to attain a satisfactory blood concentration In infants absorption is much more constant and therapeutic blood levels can be reliably maintained when doses of 100 000 units of penicillin G are given four hourly (Murray and Crawford 1951) Cathie and MacFarlane (1953) claim that as an oral preparation N N′ dibenzylethylenediamine penicillin is superior to any other

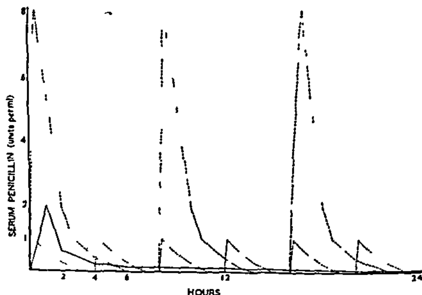


Fig 1 Diagrammatic Comparison of Blood Levels after various Intramuscular Doses of Penicillin.
50 000 units of aqueous penicillin given 4 hourly
300 000 units of aqueous penicillin given 8 hourly
a single dose of 300 000 units of procaine penicillin in aqueous suspension ————

penicillin derivative they tested they found that in children a satisfactory blood level was maintained with six hourly doses of 300 000 units They also reported uniformly good absorption amongst a small group of adults to which this dose was given If these findings are confirmed our views on administration of oral penicillin for older children and adults may need reconsideration

To sum up penicillin can be given systemically by a number of different methods the choice in any given instance will depend on the severity of the infection the sensitivity of the organism the type of patient and various economic and administrative factors Thus while a single large dose of penicillin will cure acute gonorrhœa

owing to the extreme sensitivity of the gonococcus, a six weeks course of at least 2 to 4 million units a day is needed for the treatment of subacute bacterial endocarditis where the organisms are commonly less sensitive and the body's local defence measures negligible In the more severe infections intramuscular or subcutaneous injections of aqueous benzyl penicillin (G) are to be preferred since higher and more reliable blood concentrations can be *maintained* than by any other means The slowly absorbed preparations are however, valuable in that being given less frequently, they cause less disturbance to the patient, they are particularly well suited to general practice and out patients' departments the therapeutic efficacy of procaine penicillin in acute staphylococcal infections has been confirmed by clinical trial (Griffiths *et al* 1949 and 1950) Many repository preparations are fortified with benzylpenicillin so that higher initial blood concentrations are achieved Proof of the reliability of the oral route is so far confined to infants and young children

Local Administration

Penicillin may be applied to the site of infection in many ways, and generally for one of two reasons—that of economy or more often, in order to obtain concentrations unobtainable by systemic administration The last is particularly true of intrathecal injections since, owing to the size of the molecule very little penicillin reaches the cerebro spinal fluid from the blood even when the concentration is high To avoid reactions it is essential that impure penicillin or solutions containing preservatives should not be given, 10 000 units of sodium benzylpenicillin is a usual dose this will maintain an adequate level for twenty four hours

Penicillin solutions may often with advantage be injected into serous sacs such as *infected pleural or joint cavities, into nasal* sinuses and abscess cavities the dose depending upon the size of the cavity In the same way that penetration of penicillin from the blood stream into these cavities is slow so is absorption from them and high concentrations will remain often for several days

Penicillin may be applied to wounds in solution, as an ointment in a simple base or in a powder usually containing a sulphonamide (preferably sulphathiazole) and often streptomycin External infections of the eye may be treated either by the instillation of aqueous solutions at hourly intervals or by ointments applied every two or three hours Since it does not penetrate readily into the interior of the eye from the blood stream, in deeper infections penicillin is generally injected subconjunctivally, if a dose of

1 000 000 units is given with adrenaline a high intraocular concentration is maintained for over twenty four hours

Bacteria do not appear readily to become resistant to penicillin under natural conditions since the widespread therapeutic use of penicillin has with one exception resulted in no great increase in the incidence of resistant strains Further in the case of this exception *Staph aureus* it is now generally agreed that the high proportion of resistant penicillinase producing strains found in hospitals is the result of cross infection the majority of staphylococcal infections developing outside hospital are fully sensitive to penicillin

STREPTOMYCIN

Streptomycin is a basic substance which is commonly used as the sulphate hydrochloride or calcium chloride complex and also in a hydrogenated form dihydrostreptomycin

Properties Streptomycin does not reach the circulation when given by mouth not because it is destroyed like penicillin but because it is not absorbed It remains active in the gut and can be given orally to achieve a local effect on the intestinal flora For a systemic effect it must be given parenterally Absorption after intramuscular injection is not quite so rapid as penicillin neither is excretion after a dose of 1 gm a detectable amount can be found in the blood eight or more hours later Streptomycin diffuses into the tissues from the blood stream but does not reach the cerebro spinal fluid or the interior of the eye in any significant concentration it is excreted in the urine where very high concentrations are attained

The range of the antibacterial activity of streptomycin is wide in addition to the species sensitive to penicillin the gram negative intestinal organisms and the tubercle bacillus are susceptible to its action There is however considerable variation in the resistance of individual members of most species Streptomycin is strongly bactericidal and differs from penicillin in that the rate of killing increases progressively with the concentration At concentrations such as those obtainable in the urine killing is extremely rapid—a matter of minutes in *in vitro* conditions—but streptomycin suffers from the grave disadvantage that bacteria which survive contact with it are extremely liable to become resistant Such a high degree of resistance as to make further treatment useless may for instance develop amongst coliform organisms within twenty four hours of the start of treatment For tubercle bacilli which multiply more slowly than the majority of bacteria the time needed for the

development of resistance is fortunately longer, probably at least five weeks

From these considerations it would appear desirable during therapy to obtain the highest possible concentrations of streptomycin in the tissues in order to rid the body of infection before resistance develops In practice these concentrations are limited by the very considerable toxicity of this drug, in fact streptomycin therapy may be said to be governed by two factors, the risks of toxicity and of development of bacterial resistance

Toxicity Eighth nerve damage is the most common and important toxic manifestation of streptomycin, the earliest symptoms are vertigo and inco ordination deafness may occur in severe cases These effects may be permanent but there is generally some recovery particularly when the amount of damage has been slight Eighth nerve damage never occurs after the short courses of treatment of five to ten days duration which are used for acute infections, though the daily dose may be as high as 4 gm but during long continued treatment its frequency and severity are directly proportional to the size of the daily dose if this is less than 20 mg per kg body weight (1 gm for an adult) permanent damage is unlikely to occur Intrathecal injections are particularly prone to give rise to toxicity Dihydrostreptomycin was introduced in the hope that its eighth nerve toxicity would be less but this has not been realized in practice Streptomycin is also more liable to give rise to allergic reactions than penicillin several cases of exfoliative dermatitis have occurred It is important to remember that toxic effects are particularly likely in patients with impaired renal function

Administration

The development of resistance during treatment probably results from the selection of bacterial mutants it has been repeatedly shown by both *in vitro* and *in vivo* experiments that resistant mutants are much less likely to arise if two or more drugs to which the organism is susceptible are given simultaneously Since this risk is particularly great with streptomycin there are probably few occasions when this drug should be given alone In the short term treatment of acute infections particularly in urinary infections with gram negative bacilli the sulphonamides provide a very satisfactory adjuvant streptomycin being usually given in six hourly or twelve hourly doses of 0 5 to 1 gm In tuberculosis the daily dose now rarely exceeds 1 gm Medical Research Council (1952) trials have shown that in pulmonary tuberculosis the development of resistance is delayed and clinical results are better when streptomycin is given

with P A S than when either drug is given alone The results suggest that 5 gm given orally four times a day is a satisfactory dosage of P A S Further trials (M R C 1953) have shown that streptomycin plus isoniazid (100 mg orally twice a day) was quite as effective as streptomycin plus P A S in preventing the emergence of strains resistant to streptomycin Long term results are needed before the final assessment of these various combinations of drugs can be made Although most of this evidence has so far been obtained from pulmonary tuberculosis it is most probable that the general con clusions are applicable to genito urinary and other forms of tuberculosis

THE "BROAD-SPECTRUM" ANTIBIOTICS

The three antibiotics chloramphenicol aureomycin and terra mycin are for convenience considered together because they have a very similar range of antibacterial activity are all well absorbed after ingestion and have all been available long enough to have established an important place in therapeutics

It should be noted that aureomycin and terramycin are closely related chemically a fact indicated by their official names chlor tetracyclene and oxytetracyclene respectively

General Properties All three drugs remain potent for long periods in the dry state but whilst in solutions chloramphenicol (Chloromycetin) and terramycin are relatively stable aureo mycin rapidly loses its activity Chloramphenicol is very insoluble in aqueous conditions but readily soluble in propylene glycol in which vehicle it has been administered locally to aural and wound infections

Owing to their extreme bitterness chloramphenicol and aureo mycin are given by mouth in capsules or to children, in suitably flavoured elixirs Terramycin is usually given in sugar coated tablets All are rapidly absorbed from the alimentary tract After a single dose of average size significant amounts are found in the blood within two hours the peak being attained after three to four hours in the case of chloramphenicol and between four and six hours in the case of aureomycin and terramycin Higher blood concentra tions can be obtained with chloramphenicol than with either of the other two drugs but as chloramphenicol is rapidly metabolized to an inactive nitro compound after six hours the concentrations are lower than those present after similar doses of aureomycin and terramycin bacteriostatic levels, however, usually persist for twenty four hours after a single dose of 1 gm These drugs are all rapidly excreted in the urine, where very high concentrations are

found, though the bulk of the chloramphenicol is inactive, sufficient of the active form is excreted to give good therapeutic results Owing to the combination of rapid absorption with rapid inactivation, little active chloramphenicol is found in the large gut Both aureomycin and terramycin, on the other hand, exert a very profound effect on the intestinal flora

Dosage In the case of all three antibiotics satisfactory blood concentrations can be maintained with six hourly and generally with eight hourly doses Dosage with chloramphenicol is usually calculated on the basis of 50 mg per kg of body weight per diem the dose being reduced by one half when clinical improvement takes place The daily dose of aureomycin and terramycin varies from 1 to 3 and 1 to 5 gm respectively, 2 gm being satisfactory in most cases Preparations of these drugs suitable for intravenous injection can be obtained for patients unable to swallow but treatment must be continued orally as soon as possible since the risk of phlebitis is not inconsiderable A very large range of preparations including even tooth pastes is available for local application

Toxicity The commonest complications of treatment with these antibiotics are gastro intestinal , nausea, vomiting and epigastric discomfort are frequent they are usually mild but may be so severe as to stop treatment These symptoms are more often caused by aureomycin than by chloramphenicol or terramycin Diarrhœa which is in the same way commoner with aureomycin, being associated with the very marked reduction in the intestinal flora may be accompanied by a distressing pruritus ani The incidence of sore mouths and black tongues is almost certainly related to disturbances in the normal oral flora rather than to vitamin deficiencies though these may occur after prolonged therapy The not infrequent association of moniliasis—and rarely, aspergillosis—with antibiotic therapy is also probably due to the same cause so is the rare but frequently fatal enteritis associated with resistant staphylococci

A very much more serious form of toxicity is the depression of bone marrow function that has been reported after the use of chloramphenicol Substances having in their chemical structures a benzene ring with attached amino or nitro group are known to be liable to affect the bone marrow Chloramphenicol has this type of structure Until more information is available as to the incidence of this complication there seems no need to discard a very useful therapeutic agent but when the drug is used a watch should be kept for the early symptoms of marrow damage, particularly during long continued or repeated treatments

Antibacterial Activity All three have what is commonly referred to as a broad antibacterial spectrum that is to say their range of activity includes not only the gram positive bacteria and gram negative cocci generally susceptible to penicillin but many of the gram negative bacilli, the rickettsiæ and some viruses Individual species and strains within the species may vary considerably in their susceptibility to one or other of these drugs In general the gram negative intestinal organisms are more susceptible to chloramphenicol than to aureomycin or terramycin, chloramphenicol being the one drug of proved efficacy in enteric fever Aureomycin and terramycin, on the other hand, are more active against the streptococci In the treatment of undulant fever aureomycin has been found superior particularly when combined with streptomycin Two species of gram negative intestinal bacteria of particular importance to the surgeon *Proteus vulgaris* and *Pseudomonas pyocyanea* exhibit exceptional resistance to all three antibiotics in spite of many statements to the contrary individual strains vary

TABLE I —*Comparative Susceptibility of Some Common Infections to Different Therapeutic Agents*

Infection by	Drug					
	Sulphonamides	Penicillin	Streptomycin	Chloramphenicol	Aureomycin	Terramycin
Str pyogenes	(5)	5	3	3	4	4
Str pneumoniæ	(5)	5	3	2	4	4
Str fæcalis	2	4	3	2	5	
Str viridans	1	5	3	2	4	4
Staph aureus	(2)	(5)	3	3	4	4
N gonorrhœæ	(4)	5	3	3	4	4
N meningitidis	5	5				
Salm typhi	1	0	1	4	1	1
Bact coli (in urine)	(5)	2	(5)	4	3	3
Hæmophilus influenzæ	2	2	3	5	4	4
Proteus vulgaris	2	3	( )	(2)	(2)	(3)
Ps pyocyanea *	(2)	0	(5)	(2)	(2)	(3)
M tuberculosis	0	0	5	1	1	1
Actinomyces israeli	2	5	3	3	3	3
B anthracis	1	5	3	2	4	4
Gas gangrene bacilli	–	4	0	3	4	4

5 = greatest therapeutic efficacy
4 3 2 = descending degrees of susceptibility
1 = little or no therapeutic effect though causal organism sensitive to some extent *in vitro*
0 = organism insensitive *in vivo* and *in vitro*
( ) = some infections are insusceptible because the infecting strain is initially resistant
* = highly susceptible to polymyxins B and E

very greatly a number are susceptible to chloramphenicol but only a few to aureomycin or terramycin *Ps pyocyanea* is highly sensitive to the polymyxins Successful results have been obtained in both prophylaxis and treatment of human infections by local and by systemic use of polymyxins B and E, A and D are too toxic for systemic administration

Aureomycin differs from chloramphenicol and terramycin in that its action is purely bacteriostatic chloramphenicol is actively bactericidal the action of terramycin being intermediate Terramycin in its range of activity very closely resembles aureomycin

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CHAPTER III

ANÆSTHESIA

T CECIL GRAY

Introduction

The introduction of curare to anæsthesia in 1942 has been followed by the development of many synthetic substitutes and the evolution of new anæsthetic techniques which because of their low toll in terms of post operative morbidity and the ideal surgical conditions which they afford have played a very significant part in the advance of surgery during recent years

Control of the respiratory activity of the patient is no new development but recently anæsthetists have sought and achieved some control of the circulation of their patients in order to reduce bleeding and also to facilitate surgery of the heart and great vessels

These two advances form the subject of this chapter

THE RELAXANT AGENTS

Curare was first used in 1912 by Laewen of Leipzig but the respiratory depression which it caused delayed the development of its use in clinical medicine for more than thirty years In 1942 Griffith and Johnson of the Homeopathic Hospital Montreal having witnessed Bennett administering Intocostrin a purified extract of curare in order to modify convulsive therapy used the same extract to obtain muscular relaxation in general surgery In this country King in 1935 had succeeded in abstracting a pure alkaloid —*d* tubocurarine chloride—from crude curare and Gray and Halton (1946) reviewed the use of this alkaloid during anæsthesia in over 1,000 cases This was only the beginning of interest in the development of drugs which provide relaxation without having detrimental side effects Chemists pharmacologists and anæsthetists have all participated in the search for satisfactory substitutes for the arrow poisons and the result has been the appearance of a series of synthetic drugs which vary in the manner in which they act and in the effectiveness and duration of the relaxation which they provide These drugs—the relaxants—have as will be seen radically altered the whole conception of anæsthesia

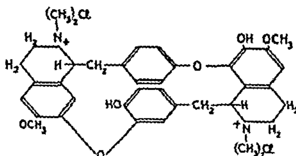
With the exception of mephenesin which has not fulfilled its early promise the drugs used in anaesthesia to produce paralysis all exert their effects at the myoneural junction and may be divided into those acting by (A) competitive inhibition and (B) depolarization

Competitive Inhibition

On arrival of a motor nerve impulse to a striated muscle fibre at the end plate region acetylcholine is released The acetylcholine before being hydrolysed by cholinesterase is believed to alter the polarization of the region and thus produce a transient potential difference between it and the surrounding area, which excites the muscle fibre and causes it to contract *d* Tubocurarine chloride and substances acting in a like manner are presumed to occupy the acetylcholine receptors on the limiting membrane of the motor end plate and thereby prevent the depolarizing activity of the acetyl choline These agents may be regarded as exerting their action by competing with the acetylcholine for the receptors It is clear that anything which tends to increase the concentration of the acetyl choline in the region of the end plate will reinforce its ability to compete for the receptors and therefore tend to antagonize this type of curarizing agent Neostigmine and other anticholinesterase drugs by inhibiting the breakdown of acetylcholine, have just this effect

d Tubocurarine chloride its dimethyl ether and gallamine triethiodide act by competitive inhibition and are in constant clinical usage

***d* Tubocurarine Chloride** is the active principle of tube curare and was isolated in crystalline form by King in 1935 and is now prepared by extraction from a single plant source—the Chondodendron Tomentosum It is a quaternary alkaloid and in chemical constitution it is a bisbenzyl isoquinoline derivative having the following structural formula



Pharmacology Its main effect is to produce paralysis of striated

voluntary muscles It has no effect on the cardiovascular system or the parenchymatous organs, but it has two side actions which are of importance

(*a*) Ganglion blocking activity In large doses *d* tubocurarine chloride blocks the transmission of impulses through the autonomic ganglia—affecting the sympathetic ganglia more than the parasympathetic This is of no significance clinically for very large doses are required for it to be evidenced by even transient falls in blood pressure It may however explain the slow pulse commonly observed in anæsthesia when *d* tubocurarine is used and the apparent rarity of circulatory reactions to traumatic stimuli even in light anæsthesia

(*b*) Histamine production When *d* tubocurarine chloride is perfused through voluntary muscle it liberates histamine (Gregory and Schildt 1947) and injected intradermally it produces a typical wheal Clinicians have always feared that the histamine thus released might cause severe bronchospasm in human patients Although this complication has been observed experimentally in animals (West 1938) and in humans during treatment of tetanus (West 1936) and during anæsthesia (Whitacre and Fisher 1945) it is to day a rare complication thanks to increasing experience in its use and also to the great purity of drugs which are available

Dosage The usual initial dosage of *d* tubocurarine chloride is 2 mg per stone (6 3 kg) body weight After intravenous injection its effects are apparent in one to one and a half minutes and last at maximum intensity for twenty five to thirty minutes It is advisable to give a small test dose initially of one third of the induction dose this will reveal both undue resistance and sensitivity, which undoubtedly occur

Indications and Contraindications The chief anæsthetic indications for the use of *d* tubocurarine chloride are to provide relaxation and control of the respiration during abdominal and thoracic surgery

Its use is absolutely contraindicated in patients suffering from myasthenia gravis who show an extreme degree of sensitivity to this type of relaxant agent and in cases with respiratory obstruction

Where relaxation is required only for the shortest periods drugs with a shorter duration of action such as gallamine triethiodide or suxamethonium are to be preferred

Synthetic Substitutes for *d* Tubocurarine Chloride (*a*) **Dimethyl Tubocurarine Bromide** This alkaloid prepared synthetically from *d* tubocurarine chloride, is identical in its pharmacological actions The duration of its paralysant effect is however shorter lasting

twenty to twenty five minutes and being twice as potent the dosage required is half that of *d* tubocurarine chloride

(*b*) **Gallamine Triethiodide (Flaxedil)** The paralysant action of gallamine resembles that due to *d* tubocurarine chloride but lasts for a shorter time (twenty minutes) It has autonomic ganglion blocking activity which differs from *d* tubocurarine chloride in that the parasympathetic ganglia are more affected than the sympathetic (Doughty and Wylie 1951) The vagal block with sympathetic predominance thus produced results in tachycardia which is always seen following its administration It is less active than *d* tubocurarine chloride in liberating histamine

Dosage Eighty to 100 mgm gallamine triethiodide is equivalent to 15 mgm *d* tubocurarine chloride A test dose is advisable

Indications and Contraindications These are similar to those for *d* tubocurarine chloride but it is more suitable for use when an effect of shorter duration is required As it dilates the bronchi and is less active in histamine release it is especially indicated in asthmatics but is contraindicated in patients who have a poor myocardium on whom the tachycardia which follows its use will be an unnecessary strain

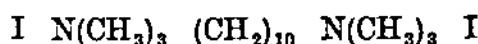
(*c*) **Laudolissin** This new compound has a chemical structure similar to that of *d* tubocurarine chloride in that it is a bisbenzyl isoquinoline derivative but differs in that it is heterocyclic and has a decamethylene side chain Its action is slower in onset than that of *d* tubocurarine chloride and the duration of its effect is considerably longer It has no marked effect on the autonomic ganglia or the vagus and in histamine release activity it resembles *d* tubocurarine chloride It is approximately half as potent as *d* tubocurarine chloride—2 mgm being equivalent to 1 mgm of the curare alkaloid Its use is indicated only in patients requiring relaxation for a considerable length of time

Depolarization

Certain substances depolarize the end plate region of the myoneural junction If the depolarization which they produce is lasting acetylcholine appearing in response to a motor nerve stimulus will no longer produce a transient potential difference and a myoneural block will be present In this case anticholinesterase agents, which increase the concentration of acetylcholine, will obviously not antagonize the block but will in fact tend to intensify it The drugs which are used as relaxants in clinical practice and which act in this way are decamethonium and the two short acting substances suxamethonium (succinylcholine) and suxethonium The initial

depolarization caused by injections of these substances may cause muscular fibrillations and twitching This is not usually evident when decamethonium is used but is marked after suxamethonium In fowls spastic paralysis always follows injections of these drugs and this fact is used as a test for substances which act in this manner

Decamethonium Iodide Decamethonium iodide has the following simple structural formula



$$I \quad N(CH_3)_3 \quad (CH_2)_{10} \quad N(CH_3)_3 \quad I$$

Its use in anæsthetic practice was first reported by Organe (1949) and although received at first with considerable enthusiasm as a possible substitute for curare it has been displaced by later products which have proved more generally reliable Following its injection the distribution of the paralysis is clinically indistinguishable from that caused by *d* tubocurarine chloride It has considerably less ganglion blocking activity than either *d* tubocurarine chloride or gallamine triethiodide and intradermal tests on man suggest that it has about half the histamine producing activity of *d* tubocurarine chloride

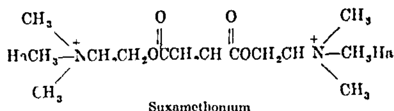
The maximum effect of decamethonium iodide lasts about twenty minutes but there is a tendency after large dosage for its maximum effect to be followed by a less marked but longer persisting paralysis Pentamethonium and hexamethonium bromide have been suggested as antidotes and do in fact partially reverse the paralysis but they are powerful ganglion blocking agents and produce as a consequence severe hypotension Their antagonistic action is incomplete

Dosage Initial dosage of decamethonium iodide is from 3 to 6 mgm given intravenously The intramuscular route has been used but the onset of the paralysis is delayed and its duration is less controllable

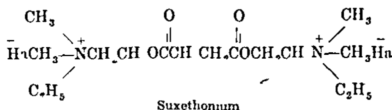
Indications and Contraindications Decamethonium does not as was at first hoped spare the respiration in doses which produce satisfactory relaxation Furthermore a deeper plane of anæsthesia is generally required than that commonly employed with other relaxants It has no antidote Decamethonium has probably now little or no place in routine anæsthesia as there are available other substances which are more reliable and to which there are satisfactory antidotes It is however well tolerated by myasthenics and has a special field of usefulness in such patients but it should be noted that these patients may be hypersensitive to large doses due to a secondary block by competitive inhibition (Churchill Davidson and Richardson 1952)

Decamethonium is definitely unsuitable for use in cases of long duration and obviously for patients undergoing thoracic surgery, where controlled respiration for long periods will be required

Suxamethonium (Scoline) The relaxant drugs so far described have comparable durations of action—twenty to forty minutes It was found that esters of choline, notably the succinyl derivatives, caused depolarization block of very short duration (Bovet *et al* 1949 Buttle and Zaimis 1949) Two such compounds have been introduced into clinical practice namely the dimethyl (suxamethonium) and the diethyl (suxethonium) halide of the succinyl ester of choline, which have the following structural formulæ



Suxamethonium



Suxethonium

Ha = Halogen

The two compounds resemble each other pharmacologically with the sole difference that the paralysis caused by the suxethonium compound is rather more rapid in onset and of slightly shorter duration

Five to thirty seconds following intravenous injection of suxamethonium muscle twitching and spasms are seen followed after a further five to ten seconds by a complete flaccid paralysis of all the striated muscles The muscles of respiration are affected, and in practice relaxation and respiratory arrest are almost simultaneous in onset and of similar duration The paralysis following a normal dose of 50 mgm lasts for four to six minutes Suxamethonium is hydrolysed by both the pseudo cholinesterase present in the plasma and to a lesser extent by true tissue cholinesterase succinic acid and choline being formed

Cases of prolonged paralysis and respiratory arrest following suxamethonium have been described and there is considerable evidence which suggests that such patients have a reduced serum

pseudo cholinesterase concentration (Bourne *et al* 1952 Evans *et al* 1952) For this reason care should be taken when administering this substance to patients with liver disease or who are suffering from severe anæmia cachexia, starvation or from poisoning with certain insecticides

Suxamethonium has neither significant histamine production activity nor ganglion blocking effects

Dosage The initial dosage of suxamethonium should be from 25 to 50 mgm For more prolonged relaxation after the usual initial dose supplementary increments of 10 to 20 mgm may be given every third minute or when there are signs of returning respiratory activity, or an attempt may be made to maintain an even blood concentration by an intravenous infusion containing 1 to 2 mgm of suxamethonium per ml of physiological saline A useful rate of infusion would be forty to sixty drops per minute (2 to 8 mgm)

Indications and Contraindications Suxamethonium is especially useful to facilitate endotracheal intubation prior to anæsthesia for neurosurgery plastic surgery ear nose and throat surgery or other surgical procedures in which relaxation is not necessary It has also completely changed the picture of the anæsthesia for endoscopies as has been illustrated by a recent review of over 1 000 cases of bronchoscopy and œsophagoscopy (Butt 1952) In orthopædic clinics it will be found a useful accessory to anæsthesia for reduction of fractures dislocations and mobilization of joints etc Its employment in cases of longer duration either by intermittent injection or continuous infusion is still in the experimental stage and although there have been encouraging reports it is probable that the longer acting agents will be more generally preferred for this purpose

Treatment of Respiratory Depression when Relaxant Agents have been Employed

✓The relaxant agents paralyse the muscles of respiration✓ The absence of spontaneous respiration during operative procedures holds no terrors for the modern anæsthetist in fact it is often desirable and a necessary part of the anæsthesia ✓However normal and adequate respiration may be slow to reappear at the end of the operation and this may be due to misjudgment by the anæsthetist or occasionally to hypersensitivity to the drugs which have been used Whatever may be the cause the first treatment of such a condition must always be artificial respiration by inflation of the lungs with oxygen A decision must then be made as to the cause of the depression remembering that it may be due to hyperventila

tion with consequent acapnœa or to central depression, as well as to residual activity of the paralysant drugs.

There are no clinically useful antidotes to the drugs acting by depolarization and, if the respiratory depression is due to these treatment must be by continuing artificial respiration until full and complete respiration has returned. In the treatment of such conditions a Drinker apparatus may be found extremely useful

Since the work of Pal (1900) it has been known that the anticholinesterase drugs were powerful antidotes against the curare alkaloids. They are, in fact effective against all the drugs acting by competitive inhibition Neostigmine is twice as effective as physostigmine in this respect and exerts its antagonistic effect probably by a direct anti curare action as well as by its anticholinesterase activity Because of the latter it has marked muscarinic effects and when neostigmine is used as an antidote it must always be preceded by a dose of atropine, otherwise bradycardia *perhaps even cardiac arrest,* intestinal overactivity and salivation are likely to result It is common practice to give a dose of atropine 1/100 to 1/50 grain (0 65 to 1 3 mgm) intravenously and after two minutes to follow this with a dose, in an adult, of 2 5 to 5 mgm of neostigmine. The neostigmine should be administered *only when there is some spontaneous respiratory activity*, as only then can the patient s response to the antidote be assessed In the absence of such indication there may be a tendency to give repeated doses of neostigmine and overdose of this substance may itself produce paralysis of voluntary muscles If cyclopropane *which has itself parasympathomimetic* properties has been the anæsthetic used or the patient has a tendency to vagal over activity which may be manifested by the history of asthma or vasovagal syncopy, the neostigmine should be carefully given in divided doses

Effect of Relaxant Agents on Anæsthetic Practice

The relaxants have revolutionized anæsthetic technique in that they have removed the necessity for the deeper planes of anæsthesia During deep anæsthesia there is a significant impairment of circulatory control because of depression of the vasomotor centres and compensatory reflexes The result of this is that the patient has lost the power to compensate for blood loss and for changes in position and temperature Moreover, after deep anæsthesia there will be a prolonged period of recovery during which respiratory activity may be minimal the cough reflex depressed and the danger of respiratory obstruction and aspiration of vomitus ever present. Anyone used

to these conditions who visited a modern surgical unit could not fail to be impressed by the contrast presented after operation by the present day patient who within a few minutes of the end of the operation is conscious and co operative and has unimpaired respiratory and compensatory vasomotor reflexes

Hazards

These may be divided into the dangers which are entailed in the light plane of anæsthesia commonly used those associated with the paralysis of the respiratory musculature which these drugs produce and those associated with relaxation of the œsophageal musculature

Dangers of Light Anæsthesia There have been reports in the literature of patients becoming aware of their surroundings during operations, and other instances have occurred which have not been recorded This mishap is not made more excusable by the fact that such patients have usually exhibited a marked degree of analgesia and euphoria Insufficient care and attention to the obvious premonitory signs such as movement of a limb, a rising pulse rate or changes in the blood pressure which give ample warning of too light an anæsthesia are unforgivable It has been found that using the relaxant agents which are at present available the degree of paralysis to which a patient is submitted will not be sufficient to prevent him responding to painful stimuli Even though his respiratory musculature may be completely paralysed experience has demonstrated that such patients are still able to respond by movement of a limb to a painful stimulus The picture of a patient conscious in agony and compulsorily immobile is one which need exist only in the imagination

Stimulation of the autonomic reflex in the abdomen or thorax, during inadequate anæsthesia may produce circulatory disturbances The collapse which follows such stimulation resembles in its effects on the heart rate blood pressure cardiac output and peripheral blood flow a vasovagal syncopy During light anæsthesia such collapse is reversible in that when the stimulation ceases the patient s vasomotor tone recovers This recovery is in marked contrast to the irreversible collapse of similar ætiology which may be seen during deep anæsthesia Light anæsthesia need not be accompanied by reactions of this type if adequate protection of the patient is provided by analgesics Usually the inhalation of adequate concentrations of nitrous oxide and oxygen are sufficient but during abdominal procedures where there is likely to be considerable stimulation of the deep autonomic reflexes it is advisable to reinforce

the analgesia by the administration of more potent drugs, such as pethidine

Dangers of Respiratory Depression Because of the oxygen rich mixtures which the patient is likely to be receiving under modern anæsthetic conditions, the respiratory depression is not likely to result in anoxæmia but there may be a deficient elimination of carbon dioxide The resulting carboxæmia will be manifested by a rise in blood pressure and capillary oozing Moreover, the respiratory centre will be stimulated and any spontaneous respiratory activity which is present will be exaggerated and become bumpy and jerky giving rise to a degree of abdominal turbulence little better than the tight abdomen of old The anæsthetist must therefore perforce assist the respiration by squeezing the reservoir bag of the anæsthetic machine For many years control of the respiration has been utilized by anæsthetists to permit intrathoracic operations and in the course of time in consequence of the frequent respiratory depression following the use of relaxant drugs, it has become more common to view with equanimity the abolition of spontaneous respiration and substitute for it artificial ventilation of the lungs even in conditions which do not strictly require such fully controlled respiration It has been suggested (Gray and Rees, 1952) that the apnœic state with controlled respiration is desirable during major surgery on the abdomen as well as on the thorax, because it results in a reduction in the dose which must be given to the patient both of relaxant and of narcotic drug (Dundee 1952)

Because of the loss of tone in the intercostal muscles and diaphragm after dosage with relaxant agents there is a diminution in the size of the thoracic cavity This predisposes to under ventilation of the peripheral areas of the lung during the operation and in the recovery period During the operative procedure this is dealt with by the assisted respiration which has already been described but the return of the patient to the ward with any residual paralysis is for this reason very likely to be followed by post operative atelectasis After administration of the longer acting agents such as *d* tubocurarine chloride, it is unlikely that there will be complete recovery at the end of the operative procedure It is therefore advocated by many that neostigmine preceded of course by atropine should be injected as a routine before the patient returns to the ward It is true that with deeper anæsthesia smaller doses of relaxants may be used and there is consequently, less frequently a necessity for the administration of antidotes under such circumstances however, all the advantages of light anæsthesia

are lost and the maximum benefit is not being gained from the use of relaxant agents

Dangers due to Relaxation of the Œsophageal Musculature

Relaxation of the œsophageal musculature after relaxant agents predisposes to regurgitation of stomach contents during the induction of anæsthesia a danger obviously more imminent in cases of intestinal obstruction or other abdominal emergencies It is imperative that this latter type of case should be treated along orthodox lines have the stomach emptied and if necessary, washed out through a wide bore tube prior to the induction of anæsthesia Even in conditions where there is no intestinal obstruction an insidious reflux of gastric contents up the œsophagus may occur For this reason endotracheal intubation with a cuffed tube is advisable as a routine after the administration of relaxant agents This not only prevents aspiration of stomach contents but also ensures the perfect airway which is an absolute necessity of such an anæsthetic technique moreover inflation of the stomach and intestines which may otherwise occur during controlled respiration is avoided

THE CONTROL OF BLEEDING DURING OPERATION

Hypotensive Anæsthesia

The introduction of intravenous barbiturates cyclopropane and relaxant agents satisfied the surgeon s demands for speedy and efficient preparation of his patient for operation It soon became apparent however that these techniques gave rise to complaint on a new score —increased bleeding The failure of anæsthetists to appreciate the necessity for assisting a depressed respiration and thereby ensure adequate elimination of carbon dioxide, was probably the real cause of this new complaint Be that as it may there are some surgical techniques especially in the plastic otolaryngological and neuro surgical fields which are seriously handicapped by bleeding

An attempt to overcome this difficulty was made by Gardner in 1946 and Hale in 1947 (Hale 1948) who artificially lowered the blood pressure during neurosurgical procedures by arteriotomy withdrawal and subsequent replacement of the patient s blood

In 1948 Griffiths and Gillies of Edinburgh reported on high spinal anæsthesia for thoraco lumbar splanchnicectomy and sympathectomy The elimination of the sympathetic vasoconstrictor impulses together with the jack knife position adopted for the operation produced a dramatic fall of systolic pressure—no pressure being recordable in the brachial artery—and in conse

quence a completely ischæmic field of operation These workers also offered an explanation to account for the absence of serious sequelæ to such degrees of hypotension They suggested that the head of pressure necessary to drive blood through the capillary bed and ensure full oxygenation of the tissues was in fact only 30 mm of mercury when the arteriolar resistance was reduced by vaso dilatation

Armstrong Davison and Enderby suggested in 1950 the use of ganglion blocking agents to produce hypotension during operation This made the technique easy and since then the indications for hypotensive anæsthesia have been extended to cover not only cases in which bleeding is a definite nuisance to the surgeon but also those cases in which blood loss is likely to be considerable if the blood pressure is maintained thereby reducing the need for transfusion of donor blood with all its attendant hazards

Techniques

Bleeding and oozing in a wound can be reduced to a minimum by the anæsthetist ensuring a clear and adequate airway full oxygenation and the adequate elimination of carbon dioxide If necessary the surgeon can render the wound more ischæmic by

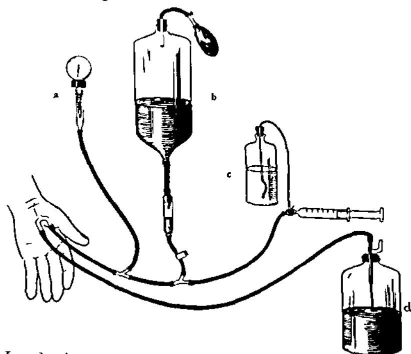


FIG 2 Apparatus for arteriotomy after Hale (1948) (*a*) Manometer (*b*) Flask for return to patient of blood under pressure (*c*) Flask containing 0 01 per cent heparin solution (*d*) Flask to receive withdrawn blood

using a local anæsthetic containing a vasoconstrictor It is obvious that an ischæmic field can also be produced by the use of deep anæsthesia but this type of hypotension and slowing of the circulation, due to depression of the vasomotor centres and myocardium, can hardly be justified

There are three principal methods in current use to achieve artificial hypotension during operation

Arteriotomy This method the least widely used has the advantage that the blood pressure can be controlled at will Briefly the procedure is to bleed the patient from an artery usually the radial into bottles containing an anticoagulant, until the blood pressure is stabilized at a suitably low level The blood is subsequently returned by the same route Fig 2 shows the apparatus used by Hale (1948) for this purpose Up to 3 litres of blood may be removed the aim being to keep the systolic pressure in the region of 80 mm of mercury and to regulate it according to surgical requirements and the patient s reaction

An important objection to this procedure is that the loss of blood is compensated for by vasoconstriction and this, combined with the loss of blood volume and the hypotension is likely to lead to tissue anoxia

Total Sympathetic Block by the Intrathecal Injection of Local Analgesics Sarnoff and Arrowood (1946) have shown that paralysis of the sympathetic nerve fibres can be produced by concentrations of local anæsthetic (0 2 per cent procaine) far below those required to produce sensory or motor block (1 5 to 2 per cent procaine) Griffiths and Gillies made use of this by permitting a spinal anæsthetic to spread upwards in such a way that in the upper dorsal region only the sympathetic fibres were affected whilst the analgesia was sufficient to cover the operative field Light narcosis was maintained with thiopentone and full oxygenation by allowing the patient to respire oxygen with if necessary assistance of the respiration Gillies appreciated the part played by posture in allowing pooling of the blood in dependent parts but insisted on the patient being maintained in the head down position in order to ensure adequate cerebral blood flow and oxygenation (Gillies 1951) During the period of hypotension the capillary circulation in the skin is usually good and the patient appears pink and dry The heart rate is usually slow between forty and fifty beats per minute The duration of hypotension depends on the type of local analgesic used post operatively the head must be kept lowered until the blood pressure has returned to normal usually a period of two to three hours

The advantages claimed for this technique are (a) the full dilatation of the arterioles ensures an adequate blood flow to the tissue capillaries despite a lowered systolic pressure, (b) the hypotension is predictable and certain, and (c) the analgesia and relaxation provided by a spinal anæsthetic are optimal

The disadvantages particular to this method are all implied in the hazards of a spinal anæsthetic

Ganglion Blockade by Drugs which Interfere with the Transmission of Impulses through the Autonomic Ganglia While decamethonium iodide (C_{10}) produces neuromuscular block, the lower penta and hexa homologues block transmission through autonomic ganglia, and thereby cause sympathetic paralysis, vasodilatation and hypotension Armstrong Davison (1950) reported on the use of pentamethonium bromide to reduce bleeding during anæsthesia, and further series of cases were published by Enderby (1950, 1951)

As with high spinal block two factors play a part in the production of hypotension by these agents

1 The creation of a state of vasodilatation by sympathetic block

2 The pooling by posture of a significant fraction of the patient's circulating blood and its storage in parts of the body distal to the site of operation

This pooling and storage of blood in dependent parts of the body may well be assisted by a relaxation of venomotor tone (Paton, 1951) and amounts to and has been termed an " internal phlebotomy The method entails therefore a loss of circulating blood volume accompanied by vasodilatation—a condition of affairs greatly different from that existing after arteriotomy, in which the loss of blood volume is accompanied by vasoconstriction

The technique is as follows After the usual premedication anæsthesia is induced with an intravenous barbiturate, a muscle relaxant, if required and maintained with nitrous oxide and oxygen, with the addition of analgesic doses either of volatile anæsthetic agents or intravenous pethidine When the anæsthesia is stabilized the patient is placed on the operating table and a posture assumed which is suitable for the operation, and which will allow the blood to gravitate to dependent parts of the body a review of the various positions which may be adopted has been given by Enderby (1951) A dose of pentamethonium (20 to 30 mgm) or of hexamethonium (20 to 50 mgm) is administered and the effects observed Older patients will require the smaller dosage Increments of the drug are given until the required degree of hypotension is attained Up to 150 to 200 mgm may be required The aim should be to

maintain the systolic blood pressure in the region of 70 mm of mercury If the hypotension becomes too extreme this can be rectified by altering the posture of the patient and if necessary by the intravenous injection of small doses of a vasoconstrictor agent such as Methedrine Throughout the operation full oxygenation of the patient must be ensured by maintaining a high percentage of oxygen in the anæsthetic mixture being respired by ensuring a free and adequate airway and when necessary by assisting the respiration

While this technique has obvious advantages over either arteriotomy or total spinal anæsthesia it has disadvantages The methonium compounds are most certain in their effects in hypertensive and elderly patients whom many would consider unsuitable subjects for this procedure The younger and healthier the individual the less these drugs can be relied upon to achieve the necessary degree of hypotension unless a fairly deep plane of anæsthesia accompanies their administration A further disadvantage arises from the necessity to posture patients It is not always convenient for the site of operation to be raised above other parts of the body and the necessity for a head up tilt in operations on the head neck and upper parts of the body carries with it the danger of an impaired cerebral circulation

Precautions to be taken by the Surgeon during Hypotensive Anæsthesia

In order to avoid reactionary hæmorrhage it is important that any bleeding point which is observed no matter how little blood oozes therefrom should be hæmostatically sealed Clotting and retraction will prevent bleeding from the smaller vessels post operatively if the blood pressure is only permitted to recover slowly For this reason any rapid restoration to normal of the blood pressure, such as might follow the injection of a dose of vasoconstrictor agent or a sudden change in position of the patient is contraindicated Any bleeding that does occur due either to severance of a large blood vessel or due to bleeding following an inadequate degree of hypotension is likely to have more serious consequences when the vasomotor responses are abolished It is of the greatest importance that blood should be replaced adequately and quickly under these circumstances For this reason also the production of hypotension in a patient who is already bleeding is extremely dangerous

Discussion of the Hypotensive State

There can be no gainsaying that a surgeon s task is greatly facilitated by an ischæmic field of operation and few will argue

against the principle that a pint of the patient's own blood is to be preferred to two pints out of a bottle. A condition of lowered blood pressure however no matter how controlled obviously entails a radical alteration in the patient's circulatory dynamics.

It is generally agreed that in the presence of a significant degree of arteriosclerosis or atheroma, conditions which will further reduce blood flow, the use of this technique is absolutely contraindicated.

Only a beginning has been made to the investigation of patients with hypotension and it is probably true to say that none of the work which has yet been produced is sufficiently final or authoritative to justify any definite conclusions in regard to the safety of this procedure. The following is a very brief review of the important research work which has been undertaken to shed light on the effects on various systems and organs of lowering the blood pressure.

Effect on Heart. Shackman *et al.* (1952) have estimated the cardiac output and studied the peripheral blood flow in patients during hypotensive anæsthesia. They found that in all cases the cardiac output was materially reduced, sometimes to a profound degree. The degree of reduction in cardiac output bore no relation to the blood pressure, an important and perhaps disturbing point. They considered that this diminution in output was due to the pooling of blood on the venous side of the circulation. They point out that with a reduced cardiac output without compensatory constriction of the renal vessels or the vessels of the skin and muscles, which in fact do not occur in anæsthetized patients after methonium compounds, there is a serious danger of a considerable reduction in blood flow through the coronary and cerebral vessels and through the liver. Slight electro cardiographic changes which might indicate coronary insufficiency have in fact been reported (Armstrong Davison 1950).

Effect on Kidneys and Liver. Evans and Enderby (1952) compare the incidence of proteinuria and the appearance of red cells and casts in the urine in a series of fifty patients who were anæsthetized without hypotension with that in a similar series receiving the same type of anæsthesia but with hexamethonium and a hypotension of 55 to 80 mm. of mercury. Although there was a slightly higher incidence in the latter series, the difference between the two was not statistically significant. However, using the inulin clearance and *p* amino hippurate clearance test Miles *et al.* (1952) found a considerable fall in renal blood flow and glomerular filtration rate during anæsthesia but an insignificant change when hypotension induced by pentamethonium was superimposed. Both these observers and Evans and Enderby (1952) stress the fact that the patients employed

were presumed to have normal arteries and kidneys and that different results might be expected in diseased conditions An important point for anæsthetists to remember is that these com pounds are excreted by the kidneys and that impairment of renal circulation is likely to delay their excretion and thus prolong their action

Using macroscopic changes as an indication of liver hypoxia Bromage (1952) observed that in fourteen out of seventeen patients submitted to anæsthesia and hypotension the colour and consistency of the liver suggested hypoxia When the systolic pressure was between 45 and 60 mm of mercury the liver appeared cyanosed and turgid and rubbery The organ quickly became pink and of normal consistence when the pressure was restored by injection of a vaso constrictor agent

Effect on Cerebral Blood Flow The estimation of cerebral blood flow is beset with difficulties but in several centres research is being conducted to elucidate the state of the cerebral circulation during hypotensive anæsthesia The estimation of oxygen differences in cerebral venous blood (Saunders 1952) is an inaccurate estimation of cerebral blood flow and as has been pointed out by Hughes (1951) actual total cerebral blood flow must be estimated before any real conclusions may be drawn Nilsson (1953) has ingeniously applied the flicker fusion test of cerebral damage to estimate cerebral anoxic changes after hypotensive anæsthesia and his preliminary results have been suggestive that damage does occur— but these results were uncontrolled and therefore by no means definitive

Finally all are agreed that the danger of ischæmic anoxia of impor tant organs is very much greater if the blood pressure is allowed to fall below 70 mm of mercury

Side Effects of Methonium Compounds There are certain side effects of the methonium compounds not directly related to the hypotension Loss of accommodation due to paralysis of the ciliary muscle is a common but not important sequela of their administra tion In conscious subjects when given for the treatment of hyper tension their effect at the vagal ganglia may be evidenced by nausea abdominal distension constipation and occasionally para lytic ileus and an unusual incidence of the latter complication has been reported after anæsthesia in which these drugs are used

Summary Accidents have occurred when this technique has been used and they can be attributed to one of three causes (*a*) inexperience in the use of the technique (*b*) its use in unsuit

able cases—an ever increasing group (c) a definite morbidity and mortality associated with hypotension or the drugs used

Indications and Contraindications for the Use of Hypotensive Anæsthesia

In view of the little authoritative work which has yet appeared on the hypotensive state caution must be exercised in defining indications for its use There is a clear and justifiable case for reducing vascularity and bleeding in certain otolaryngological operations as for fenestration in neurological surgery and in certain plastic operations It is extremely doubtful however, in the present state of our knowledge whether the use of this method is justified merely in order to ease the work of the surgeon in cases in which it is not otherwise specially indicated Anæsthetists are now well able to reduce oozing and hæmorrhage to reasonable proportions without resort to this expedient The claim that the methonium drugs, by their autonomic blockade reduce the incidence of circulatory deterioration following trauma (Wyman, 1953) has yet to be established

The following would seem to be the absolute contraindications to hypotensive anæsthesia

1 The suspected presence of *arterio sclerosis* or *atheroma* of the cerebral and/or coronary vessels
2 Hypotensive states such as *Addison s disease*
3 Where, as a result of trauma there is reason to expect a *reduction of blood volume* and compensatory vasoconstriction
4 In the presence of *anæmia*, which will intensify the effects of any tendency to ischæmic anoxia
5 In the presence of *poor renal function* not only is there a risk of further damage to the kidney, but also there will be a delayed excretion of the methonium compounds
6 In *Cæsarean section*, if the maternal blood pressure falls below 80 mm of mercury there may be fœtal asphyxia due to obstruction of blood flow by the uterine tone

Although hypotensive anæsthesia has been employed for intra thoracic operations in this country the technique has not gained general favour with thoracic surgeons because of the hazard of reactionary hæmorrhage Small branches of the intercostal vessels particularly in the presence of pleural adhesions are likely to be overlooked and may cause serious trouble post operatively

In summary, this advance in anæsthesia should be received with cautious enthusiasm by those surgeons who are likely to perform

operations seriously hindered by hæmorrhage For others it should be of interest but employed only *when there are specific indications* It is no substitute for good anæsthetic and surgical techniques which together in ordinary general surgery should reduce blood loss to a minimum

Refrigeration and Hibernation

In 1938 Allen reported that reducing the temperature of a limb increased the survival time following the application of a tourniquet and reduced the condition of shock on removal of the tourniquet This latter observation has been confirmed by Blalock (1943) and refrigeration of a limb as a method of anæsthesia prior to amputation of a limb for gangrene in elderly and poor risk cases is firmly established

A more recent advance however has been the appreciation that a state of artificially induced hibernation is possible and practicable in human patients The fact that the natural protective reactions to chilling may produce more harm than the mere cold has led to the development of techniques which will remove these reflexes by sedation (Allen 1950) and by the use of ganglion blocking agents and anti histaminics (Huguenard 1951 Laborit 1952) The temperature of a patient may then be lowered by the external application of ice packs or by circulating his blood through a cooling device (Delorme 1952) Under these circumstances the meta bolism may be reduced to as much as one third below basal Under such conditions the oxygen demands are greatly reduced and are satisfied by a very reduced blood flow only the smallest dosage with narcotic agents is required to produce sleep and the circulatory reactions to trauma are minimal

This work is still experimental but is indicative of a more funda mental approach to the problems involved in extensive and radical surgery The correct therapy may not be to bolster up a failing compensatory mechanism but to lower the metabolic demands of the tissues New fields are being opened up and these advances may well play an important part in the development not only of surgery of the heart but also of radical procedures in all fields

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CHAPTER IV

√ BURNS

A B WALLACE

EXPERIENCE in the Second World War led to many advances in the treatment of burnt patients and over the past seven years with the many changes in outlook, there has been better understanding of the pathological sequels following thermal injury However different physio pathological responses cause much variation in clinical course To help to solve some of the remaining problems research projects and clinical studies are necessary in burn units set aside for the work

Classification

Burns are classified by extent and by depth Classification by extent is almost essential since the degree of shock resulting from a burn is directly related to the extent the burn is therefore represented as a percentage of the total body surface Most workers are familiar with the tables of Lund and Browder (1944), but for a rapid estimation of the extent of surface burnt use can be made of the so called Rules of Nine table in which the body is divided into sections representing 9 per cent or multiples of 9 per cent of the body surface The head and each of the upper extremities are 9 per cent of the total body surface the front of the trunk, the back of the trunk and each of the lower extremities are 18 per cent (Fig 3)

For the classification of burns by depth many descriptive values have been suggested The most simple and probably most efficient is the division into superficial and deep burns Superficial implies involvement but not destruction of skin deep implies that at some point of the burnt area there has been whole thickness loss of skin There is no indication as to whether subcutaneous fat muscle or bone has been involved but this information is considered unnecessary in a classification What is necessary is to decide whether or not there has been destruction of skin

Cope (1951) has described the burn wound as a parasite which sucks water protein and electrolytes from the plasma circulating through its depths The injury causes increased permeability of

the capillary membranes and a protein rich fluid escapes The escape is most rapid in the first eight hours after injury and continues for two days Oedema reaches its peak around forty eight hours with reduction in filtration from the capillaries as a result of recovery of their lining membrane There follows a period of fluid reabsorption and steady diminution of oedema most marked on the third day of the burn The extent of oedema can be influenced to some extent by cold and by exposure Pressure dressings have been claimed to influence oedema formation but I am not in entire agreement The oedema fluid has a greater concentration of plasma protein than tissue fluid but less than that of plasma the electrolyte pattern is that of plasma or extracellular fluid The initial phase following receipt of a burn is a slight rise in the protein concentration of the plasma which creates an elevated colloid osmotic pressure Fluid is absorbed from the unburnt tissues into the blood stream leading to a second phase with a dilute plasma In the second phase in extensive untreated burns fluid is drawn from the interstitial space into the blood stream with a rise of colloid protein in the interstitial fluid Water is then drawn in turn from the cells into the extracellular space If dehydration is not adequately treated permanent damage may occur to renal cells

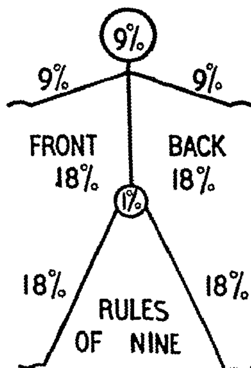


Fig 3 Rules of Nine

(Figs 3 4 and 5 by courtesy the Editor The Practitioner)

In deep burns there is destruction of red cells with the coagulation of dermal capillaries Further there may be a delayed hæmoglobinæmia which may be due either to intravascular hæmolysis of cells not completely destroyed but rendered more fragile by the same process or to a specific hæmolytic factor produced at the site of injury This process of coagulation limits the continued exudation of fluid upon the surface The whole blood loss in an extensive deep burn may account for as much as 40 per cent of the total volume deficit (Evans and Biggar 1945)

In the first twenty four hours after injury the main danger to the extensively burnt patient is from tissue anoxia and its prevention lies in the early and adequate transfusion of fresh whole blood Anoxia of even a moderate degree and over a comparatively short period will cause permanent damage to hepatic and renal cells Further in extensive deep burns there is the danger of liver damage from circulating toxins, possibly protein fractions derived from burnt tissue or altered blood components

The primary concerns in all burnt patients are the upset in fluid balance and the control of circulating toxins In assessing the *general condition of patients with burns important criteria* are the patient s age the extent and depth of the burn and the time that has elapsed since its receipt Some clinical indications of incipient oligæmic shock appear before there are any changes in blood pressure, hæmoglobin and hæmatocrit these are pallor thirst and restlessness Assessment is based on this clinical picture, although it may be confirmed later by laboratory findings

Treatment

Fluid Therapy Over the first forty eight hours the aims are (1) To make up the circulating blood volume and to keep pace with fluid loss and (2) to give the daily fluid requirements

In fluid replacement colloid and electrolyte solutions are administered intravenously in all burnt patients with over 10 per cent of the surface area involved To maintain normal renal function water should be given by mouth Patients with burns of less than 10 per cent extent can take their electrolyte requirements by mouth

Plasma and saline should be given in equal proportions so that the total protein and electrolyte content approximates to that of the fluid lost into the injured area The proportional fluid administration is as follows —

In superficially burnt patients plasma 1, saline 1

In deeply burnt patients blood 2 plasma 1 saline 1

In children under two years in place of isotonic saline a solution containing glucose 4 1 per cent and sodium chloride 0 18 per cent is employed

The administration is continued over the period of the first forty eight hours and is divided into three periods (1) 0 to 8 hours (2) 9 to 24 hours and (3) 25 to 48 hours The fluid should be given most rapidly in the first period

After forty eight hours intravenous fluid must be promptly

curtailed lest with absorption of the transudate the kidney is overloaded and pulmonary oedema produced

The best check on the efficiency of the fluid therapy is a half hourly check on the renal output Changes in urinary output precede significant alteration in hæmatocrit and hæmoglobin readings A satisfactory level of urinary output in adults is around 50 ml per hour A level of less than 30 ml per hour indicates inadequacy, although this amount may not be reached in the first twelve hour period

As a basis for estimating the amount of fluid to be administered to make up the circulating blood volume a formula has been evolved

TABLE II —*Fluid Therapy in Burns*

0–29 *per cent Surface Area*

Age	Electrolyte Solution (ml)	Plasma (ml)	Age	Electrolyte Solution (ml)	Plasma (ml)
B–3/12	7	7	8–9	44	44
3/12–6/12	10	10	9–10	46	46
6/12–9/12	12	12	10–11	51	51
9/12–1 yr	13	13	11–12	56	56
1–2	15	15	12–13	62	62
2–3	21	21	13–14	67	67
3–4	24	24	14–15	78	78
4–5	27	27	15–16	88	88
5–6	31	31	16–17	96	96
6–7	35	35	17–18	104	104
7–8	40	40	Adult	110	110

Total volume over first 48 hour period per 1 per cent surface burn

One third volume given 0–8 hours
One third volume given 9–24 hours
One third volume given 25–48 hours

The quantity of fluid given is proportional to the extent of the area into which fluid is being lost and proportional to the normal blood volume of the patient For the first forty eight hours a 70 kg adult is given 110 ml of plasma and of saline for each 1 per cent of body surface burnt The rate of administration is such that the total fluid for forty eight hours is divided into three equal parts and administered in the periods 0 to 8 hours 9 to 24 hours and 25 to 48 hours post burn Table II gives values for varying ages Extensively burnt patients lose large volumes of fluid and in replacement the surgeon must remember that the extracellular body fluid amounts to 20 per cent of the body weight and that the maximum expansion of this space compatible with safety is 50 per cent The quantities

given in Table II can be used with safety for patients with burns up to 30 per cent of surface area, but the estimated requirement for those with burns of more than this extent would exceed the safety level This safety level is equivalent to 10 per cent of the total body weight The formula given in Table III which is related

TABLE III —*Fluid Therapy in Burns*

(30 per cent Surface Area or over)

Age	Weight (kg)	Age	Weight (kg)	Age	Weight (kg)
B–3/12	5	4–5	18	11–12	35
3/12–6/12	7	5–6	20	12–13	39
6/12–9/12	9	6–7	22	13–14	43
9/12–1 yr	10	7–8	24	14–15	48
1–2	13	8–9	26	15–16	54
2–3	15	9–10	29	16–17	59
3–4	17	10–11	32	17–18	65
				Adult	70

Total volume over first 48 hour period = 10 per cent body weight in kg (equal parts colloid and electrolyte) (1 kilogram = 1 litre)

One third volume given 0–8 hours
One third volume given 9–24 hours
One third volume given 25–48 hours

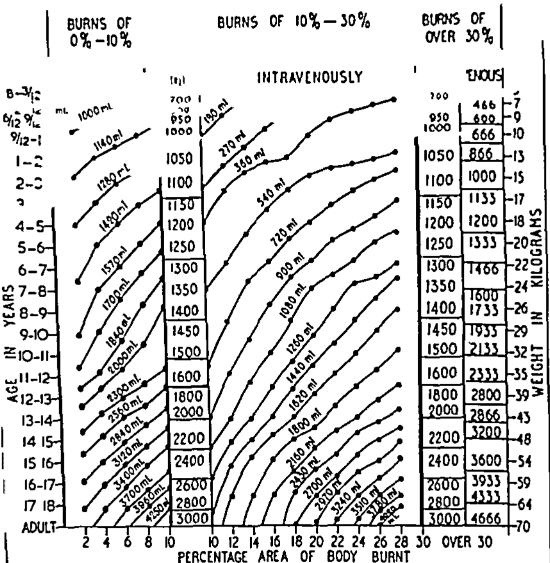
to interstitial space expansion and based on the average body weight at different ages, is employed for patients with burns of over 30 per cent extent The calculated total (10 per cent of total body weight) over forty eight hours is divided into thirds and one third is given in each of the periods 0 to 8 hours 9 to 24 hours and 25 to 48 hours post burn

In all patients in addition to the replacement fluid, the daily

TABLE IV —*Normal Daily Fluid Requirements*

Age	Metabolic Requirement (ml)	Age	Metabolic Requirement (ml)	Age	Metabolic Requirement (ml)
B–3/12	700	4–5	1 400	11–12	1 700
3/12–6/12	1 000	5–6	1 500	12–13	1 800
6/12–9/12	1 150	6–7	1 500	13–14	2 000
9/12–1 yr	1 200	7–8	1 500	14–15	2 200
1–2	1 300	8–9	1 600	15–16	2 400
2–3	1 400	9–10	1 600	16–17	2 600
3–4	1 400	10–11	1 700	17–18	2 800
				Adult	3 000

Total volume is given orally if possible in hourly or half hourly doses as orange juice sweetened tea etc



NATURE OF FLUID TO BE GIVEN	
BY MOUTH: GLUCOSE DRINKS	INTRAVENOUS FOR SUPERFICIAL BURNS ½ PLASMA ½ SALINE FOR DEEP BURNS OR MORE THAN 30% ½ BLOOD ¼ PLASMA ¼ SALINE
RATE OF ADMINISTRATION FIRST 24 HOURS	
BY MOUTH: 1/12 TOTAL EVERY 2 HRS	INTRAVENOUS ½ IN FIRST 8 HOURS ½ IN NEXT 16 HOURS
SECOND 24 HOURS	
BY MOUTH: 1/12 TOTAL EVERY 2 HRS	INTRAVENOUS ½ OF TOTAL FOR FIRST 24 HOURS

FIG 4 The Ready Reckoner

metabolic requirement must be met This fluid is required for normal renal function, and to make up loss of water from gut skin and lungs Table IV indicates the metabolic requirements for different ages This fluid is given by mouth each twenty four hours in divided hourly doses as glucose drinks or as water When there is vomiting or when drinks are refused the whole requirement must be given intravenously and the metabolic requirement added as isotonic solution In infants it is always preferable to give sodium

(a) Front (b) Back

Fig 5 The Pyrogram

chloride solutions by mouth so that the child controls the rate of absorption

It is important to remember the two types of fluid requirement—(a) *replacement and* (b) *metabolic*

From Tables II III and IV the fluid requirements can be readily estimated but the tables are intended only to be safe guides and it may be found that patients with burns of over 50 per cent may require more than the calculated amount of fluid Further adults vary considerably in weight and the figures given are for the average female or male They can be presented in the form of a ready reckoner (Fig 4) or in a type of calculator such as the Pyrogram (Fig 5) (Wallace 1953)

In the early treatment of burnt patients plasma substitutes or expanders have been used with advantage. I believe, however, that extensively burnt patients require blood and plasma to help to protect the liver and kidneys and to counter early circulating toxins.

Because assessment of the efficacy of fluid therapy is judged by urinary output a catheter should be passed into the bladder in a patient who is receiving intravenous therapy, fixed in position, clamped and released every hour. Quantities must be charted. The average daily values are depicted in Table V.

TABLE V.—*Normal Hourly Urinary Output*

Age	Satisfactory Hourly Urine Output (ml.)
B–1 yr	8–20
1–5	20–25
5–10	25–30
10–14	30–50
14 +	50–100

Supportive Measures. *Sedation.* Morphine has been found to be the most satisfactory sedative. Smaller doses are required than are usual for the age and weight and the drug should be given slowly, through the intravenous cannula, to avoid the danger of accumulation and sudden absorption of successive doses from the subcutaneous tissues.

Oxygen. Administration of oxygen at the rate of 3 litres per minute by means of intranasal catheters has been found to be the most satisfactory method. In severely shocked children aeration of the lungs is poor and it is possible that there may be some degree of central in addition to peripheral anoxia.

Posture. Careful positioning should be adopted as a first aid measure for burns of the extremities and should be continued throughout the early care.

Local Treatment. Local care is undertaken only when the general condition of the patient is considered to be satisfactory. Attention is directed towards (*a*) the limitation of œdema, (*b*) immobilization of the part, and (*c*) prevention of infection.

Œdema can be limited by early and effective posture. I believe that there is no definite evidence to support the belief that pressure dressings control œdema.

Immobilization is effected by restraint or splinting. In the early

phases of response to injury, complete rest permits the repair of tissues

Infection is controlled by systemic administration of antibiotics and by making the burnt area unfavourable for the growth and multiplication of organisms A dry cool surface deprives organisms of the warm moist environment required for their proliferation To render burnt surfaces dry the parts can be exposed to the air or can be covered with dressings which are absorptive Factors which keep the surface or the dressings moist must be eliminated at the earliest moment The terms ' open ' and closed to differentiate covered or uncovered methods of treatment should be avoided Within forty eight hours exposure of a superficial burn to the air leads to the formation of a crust impermeable to organisms a deep burn from the first is covered with an impermeable eschar The exposure method therefore is a closed method of treatment

The two forms of local care exposure and absorptive dressings far from being distinct are closely related and interchangeable Choice of method depends on such factors as the number of casualties the supplies available the geographical and climatic conditions and the experience of the surgical and nursing staff of one or other of the methods Absorptive dressings are useful for first aid in the field at the base hospital the dressings will be removed and the burn exposed or a further absorptive dressing applied

If dressings are applied they must be absorptive if they become saturated they are no longer beneficial but dangerous An entirely satisfactory absorptive dressing has not yet been evolved At the moment I employ Gamgee material

In a superficial burn the aim of treatment is to get an early crust which within three weeks will separate to leave healed skin and in a deep burn to excise the eschar within three weeks and obtain healing by grafted skin

In extensive burns the fulfilment of such aims may be prevented by several factors insufficient donor skin inability to remove all necrotic tissue at one operation the extremes of age and lack of adequate veins for blood transfusion

In my burns unit cleansing is often done under inhalation anæsthesia (cyclopropane) which can be considered a form of sedation The burnt area is cleansed with 1 per cent cetrimide or isotonic saline blisters are snipped and raised epidermis is removed The burnt surface is then gently dried with gauze As soon as possible penicillin is administered systemically either intra muscularly or in the intravenous fluid in a dosage of 0 5 megaunit

in each twenty four hours In children the oral administration of terramycin has been found to be equally effective Nevertheless I feel that any method of treatment which depends for success on the effectiveness of antibiotic therapy is doomed sooner or later to failure

The principles of exposure with immobilization are easy to fulfil in certain areas of the body and more difficult in others Regions characteristically straightforward in respect of treatment are the face upper arm and forearm, front of trunk and abdomen, genitalia, buttocks and thighs, and the more troublesome are the neck, circumferential burns of the trunk and burns of the legs, hands and fingers Deep burns present additional problems and should be considered separately

Face The patient is nursed on his back and the face exposed The eyelids, the vestibules of the nose, the lips and the external auditory canals are initially, lightly smeared with soft paraffin Discharge from the eyes nose or ears is gently removed In deep burns of the eyelids it is preferable to do an immediate tarsorrhaphy and to consider early excision and grafting

Upper Arm Elevation and relative immobilization can be achieved by suspension through adhesive strips applied to the forearm and the burnt surface can thus be exposed readily

Forearm The weight of the upper extremity can be dispersed by taking some support through suspension from the upper arm and by tapes from a stockinette mitten applied to the hand and burnt area exposed

Trunk Abdomen and Back (one aspect only) There are few nursing difficulties in these regions and the burnt surface is exposed freely The patient can be allowed up from the fourth day

Genitalia Compared with that obtained by other methods of treatment healing following exposure has been found to be rapid and nursing care straightforward Children should be placed on a frame suspended over the normal mattress

Buttocks Perineum and Upper Thighs Burnt surfaces of this distribution are best exposed In children the lower extremities are raised by skin traction from gallows splints until the buttocks are off the bed Adults with burns of the buttocks and perineum are nursed prone with the legs slightly abducted

Neck Although the principle is more difficult to apply, I still prefer to expose burns of the neck Moderate extension over a pillow is advised Systemic penicillin is continued as long as the neck continues to be moist or cracks tend to occur in the crust

Circumferential Burns of the Trunk and Legs The use of the

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Circumferential Burns of the Trunk and Legs The use of the

sectional nursing frame has proved valuable in the nursing of patients with extensive burns When expert nursing is available I still favour the exposure method It is impossible to sterilize the surface of an extensive burn and if a dressing is applied organismal growth is encouraged In circumferential burns in children I avoid dressings where possible Weight bearing parts rest on absorptive pads Gamgee bags containing at least a 1 in layer of sawdust are useful They are changed daily Further research should lead to improved forms of pads

Hands and Fingers Burnt fingers can be exposed to advantage but if the surgeon is inexperienced in the method the fingers are best covered by absorptive dressings which can be applied in two Gamgee sections (1) A mitten part to cover the palm and volar aspect of forearm and also the dorsum of hand and forearm each finger being threaded through a hole and (2) a finger or glove part with a pad attached to it for the fingers to grasp Such a sectional dressing can be prepared in small bulk and can be applied very quickly

The Deep Burn The problems of the deep burn are common to all methods of local treatment The affected surface must be kept dry and cool Patients with extensive deep burns show around the third to tenth day a toxæmia the severity of the clinical picture appears to be correlated with an elevation of the plasma non protein nitrogen This rise is due chiefly to an increase in an as yet undetermined fraction There is no doubt that skin coverage at the earliest possible moment is the ideal aim but few children and few elderly patients will tolerate extensive excision and grafting at less than two to three weeks after a severe injury except under expert hands Early excision of the burnt tissue removes a possible source of the circulating toxin as well as removing the areas which would become infected If toxæmia is marked and early excision inadvisable or impracticable exchange transfusion can be employed to advantage

The area of crusting removed when grafting is adjudged advisable depends on the total surface area of the crust and on the skin available for cover the use of homografts must be considered One of the urgent necessities to day is the training of teams for extensive rapid skin coverage The longer the period taken to obtain complete skin cover the greater the danger of local infection

General Factors

Throughout treatment the nutrition of the patient must play an important role From the third day after injury a high caloric

high protein diet must be built up and maintained At the same time some caution is required to avoid gastric irritation or distension In addition to early blood loss from an extensive deep burn, there is an inhibition of marrow activity which persists until healing is nearly accomplished This secondary anæmia is corrected only by repeated blood transfusions throughout the course of treatment

Vitamin intake must be adequate

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PART II THE ALIMENTARY TRACT

CHAPTER V

CANCER OF THE PHARYNX

SIR STANFORD CADE

Anatomical Considerations

SURGERY of the pharynx, with the exception of the treatment of pharyngeal diverticula, is the surgery of cancer of that site: only that part described as the *laryngopharynx lends itself to radical* surgery. It extends from the level of the epiglottis to the upper border of the oesophagus and can be further subdivided into the upper part or *epipharynx* above the upper border of the cricoid cartilage and the hypopharynx below it. Malignant tumours arise

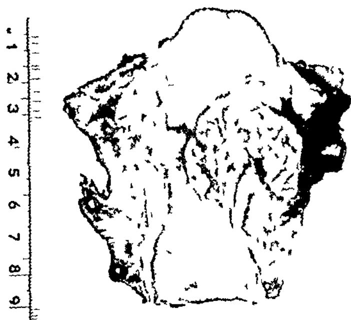


FIG. 6.—Carcinoma of the pyriform fossa [illegible] by total laryngo-pharyngectomy. Extensive lesion shown in left pyriform fossa involving the ary-epiglottidean fold and arytenoid.

in definite anatomical sites and their incidence, progress symptomatology vary with such sites of origin

Tumours of the Epipharynx These comprise two anatomical groups (1) Lesions in the region of the ary epiglottidean fold the laryngeal aspect of the epiglottis or the arytenoids, (2) lesions of the pyriform fossa (Fig 6) and of the lateral pharyngeal wall Both these groups occur chiefly in men in the fifth or sixth decades whereas the ary epiglottidean tumours are associated with some alteration of voice, those of the pyriform fossa are clinically silent and often first attract attention by their cervical lymphnode metastasis



Fig 7 Post cricoid carcinoma Operation specimen removed by laryngo pharyngectomy Extensive lesion involving the anterior wall of the hypopharynx from the arytenoid downwards

Tumours of the Hypopharynx The common site in this group is the post cricoid carcinoma situated on the anterior wall of the hypopharynx (Fig 7) It occurs nearly exclusively in women and the age incidence is earlier in the fourth decade Lesions on the posterior wall of the hypopharynx arise at a lower level at the junction with the œsophagus they occur most commonly in men and the age incidence is the fifth and sixth decades

Both types of hypopharyngeal tumours manifest themselves clinically first by some difficulty in swallowing

Clinical Considerations

Cancer of the laryngo pharynx spreads along the mucous membrane extends in the submucosal tissues and infiltrates the deep



Fig 8 Post-cricoid carcinoma Radiograph lateral view with air inflation Air as a contrast medium is preferable to barium Illustration shows profile of tongue vallecula epiglottis ary epiglottidean fold larynx and trachea The post cricoid tumour is shown as a large shadow in front of the cervical vertebra indenting and compressing the trachea antero posteriorly

layers of the cervical fascia specially the pretracheal layer It spreads by direct extension causing œdema of the surrounding structures and by lymphatic vessels to the deep cervical lymph nodes In many cases the primary growth and the lymphnodes are in direct continuity It is important to assess accurately the exact extent of the tumour as on this depends the choice of treatment Early diagnosis can be achieved in most cases if attention

is paid both by the patient and the doctor to the persistence of two cardinal signs, however slight some change in the voice, or some difficulty in swallowing Accurate diagnosis can be achieved by indirect laryngoscopy X ray examination and direct laryngoscopy and biopsy

Radiological Investigations This affords considerable help and requires some emphasis Once a presumptive diagnosis of cancer

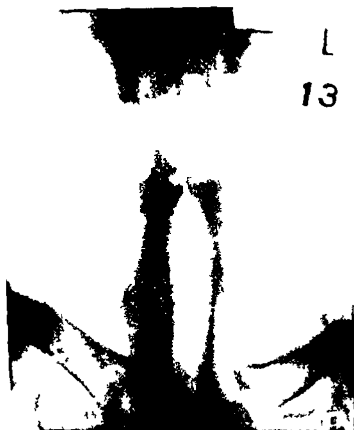


Fig 9 Tomograph antero posterior view showing true and false cords and tumour in the left pyriform fossa with oedema of ary epiglottidean fold The disease site (left) appears as a shadow

of the pharynx is made on routine clinical examination, by laryngo scopic inspection and careful palpation of the neck radiology can add considerably to the detailed knowledge of the extent of the lesion and the condition of the airway Two methods of radio logical investigation are available (1) a lateral soft tissue view of the neck using air as a contrast medium (Valsalva) This gives a profile view of the vallecula epiglottis the prevertebral space and trachea (Fig 8) The tumour is shown as a soft tissue shadow in

front of the cervical vertebra. Its size and extent especially t upper and lower limits are well defined. (2) Tomography anter posterior views show abnormalities of the cords ventricle Morgagni and subglottic space (Fig. 9). Tumours of the a epiglottic folds and of the pyriform fossa are clearly shown a contrast vividly with the normal side. A direct laryngoscop examination adds further detailed knowledge of the tumour a affords a possibility of biopsy. Histological examination esta lishes a definite diagnosis of a neoplasm and also adds the detai information of the degree of differentiation or anaplasia and gives indication as to the likely response to radiotherapy. It is of cou essential to investigate by radiology the presence or absence pulmonary metastases and by a general clinical examination the fitness of the patient for a major surgical procedure.

Surgery of the Pharynx in the Past

Attempts at removal of the pharynx and cervical oesophagus go back to Czerny who in 1877 resected a growth from the posterio region and cervical oesophagus. Pioneers in surgery of the phary include Mickulicz (1886), de Quervain (1899), Von Hacker (190 but it was Wilfrid Trotter who in 1913 described what can be co sidered as the modern method aiming at the removal of the laryn pharynx. Trotter was imbued with the belief that in the treatme of pharyngeal cancer the conservation of the larynx was of gr importance. Trotter devised the operation of lateral transthyro pharyngotomy. This gave access to the pharynx and enabled t surgeon to remove a portion of it for cancer of the pyriform fo and lateral pharyngeal wall. It conserved the larynx, obviated t need for a permanent tracheotomy and was in fact acceptable to t patient. Although a great landmark in the surgical treatment pharyngeal cancer this operation had great limitations both regards the extent of the removal of the tumour and of the surrou ing healthy tissue but also as regards operability. It was applical to early and limited growths with early if any lymphnode invasio It was a two stage operation leaving a temporary pharyngoston The limitations of Trotter's operation were an incentive to subn pharyngeal cancer to alternative methods of treatment and w the advent of radiotherapy a number of patients were treated radiation. The effect of radiotherapy in its first phase—when lo voltage X rays only were available—was poor. Even now co ventional X ray therapy at 200–250 K.V. has very little to recor mend it, even as palliative treatment. The physical limitations this range of radiation make it a disappointing method of treatme

Attempts at increasing the total dose with the then available apparatus resulted in severe post radiation effects with œdema and necrosis and hardly any control of the disease This led to the protracted fractional treatment first advocated by Coutard at the Paris Radium Institute Teleradium further improved results and some cases of pharyngeal cancer were completely controlled by it (Fig 10) yet the achievement of radiotherapy in cancer of the



Fig 10 View of indirect laryngoscopy of carcinoma of pyriform fossa A Before radiotherapy B At the end of a course of teleradium This shows disappearance of the lesion with post operative filming œdema of left arytenoid

pharynx is still meagre and contrasts very markedly with that in the intrinsic laryngeal cancer where in the majority of early cases it is now the method of choice Although there is a definite place for radiotherapy *in cancer of the pharynx specially by teleradium* telecobalt and supervoltage X rays the results on the whole by the usual available methods are disappointing and further efforts at surgical excision were called for

Modern Conception of Surgery of the Pharynx

Conservatism in surgery of cancer is dictated by humane considerations to avoid functional disability it is also put forward at times as a counsel of despair because even very extensive surgery frequently fails to cure Yet in the fight against such a formidable foe conservatism should be primarily directed to the patient and not to function It is in fact better pathology and more effective surgery to conserve the patient and not the anal sphincter the normal speech or some other function It is a conception based

on experience that it is better to be alive and free from cancer with a colostomy or a tracheotomy than to succumb to the disease with a normal method of defaecation or respiration

Such a concept of the surgical treatment of cancer dictates a policy of wide ablation of the disease In the case of cancer of the pharynx as in other malignant growths the limits of the excision are defined mainly by the extent of the disease but also by some anatomical details and its potential mode of spread To ablate



Fig 11 Post cricoid carcinoma Outline of Z shaped incision for immediate one stage reconstruction following total laryngo pharyngectomy A Incision outlined in ink B Post radiation scar showing Z shaped incision and tracheo tomy

widely a cancer of the pyriform fossa or of the post cricoid area the tissue removed should include the cartilagenous framework and musculature well beyond the actual tumour It should include the epiglottis the hyoid bone the thyroid and cricoid cartilages and at least two rings of the trachea The pharynx itself that is the laryngopharynx must be excised *in toto* from the base of the tongue at its junction with the epiglottis to the upper border of the cervical œsophagus (see Figs 11 and 12) The intimate anatomical relation between the pharynx and the larynx precludes the preservation of

the latter without a grave risk of local recurrence of the disease. The common occurrence of metastases in the cervical lymphnodes indicates the need of a block dissection of the lymphatic field and the close proximity of the thyroid at times makes it unavoidable to include part of the thyroid in the resection. Such vast excision is to day both safe and simple. The advances in anaesthesia, easy replacement of blood loss, shock preventing measures and a variety of antibiotics have rendered the excisional part of the operation a



A



B

FIG 12 Post cricoid carcinoma Total laryngo pharyngectomy following unsuccessful radiotherapy Delayed reconstruction of anterior wall of pharynx by means of tube pedicles by Mr J P Reidy F R C S A Front view B Lateral view

reasonable procedure with a very low mortality. The possibility of wide excision of the cervical viscera and the adjoining lymphnodes has two main advantages: it gives greater safety against local recurrence and it broadens the field of operability. In fact in cases of early diagnosis and small lesions it gives a far better chance of a permanent control of the disease and in the established and even advanced cases it still permits sufficiently wide excision to warrant its undertaking.

The morbidity which follows such operative procedures is however

great, especially the inability to swallow, the need of tube feeding and the continuous dribbling of saliva. Although a permanent tracheotomy is usually accepted as unavoidable the gap in the continuity of the alimentary canal remains a formidable problem. It is the repair of this gap, extending the whole length of the neck from the base of the tongue to the cervical œsophagus which has exercised the ingenuity of the modern surgeon.

Excision of the Pharynx and Larynx

Laryngopharyngectomy should include the epiglottis and thus division of the base of the tongue at its junction with the epiglottis constitutes the upper limit of the operation; distally the trachea is severed between its second and third rings and the cervical œsophagus is divided at the same level. The skin incision varies with the proposed method of closure or reconstruction. A quadrilateral flap can be fashioned by two horizontal incisions at the level of the hyoid and just above the sternal notch hinged on a broad lateral attachment, or two smaller similar flaps can be fashioned. Alternatively, a Z shaped incision provides two broad based and viable flaps (Fig. 11A). The flaps consist of skin, subcutaneous tissues and platysma. In the presence of enlarged lymphnodes the first step in the operation is a block dissection of the neck, which includes the sternomastoid muscle and internal jugular vein. In the absence of enlarged lymphnodes the sternomastoid is cut across at the lower end. The thyroid gland can be preserved, in which case the isthmus is cut across or a hemithyroidectomy is done if the thyroid is involved by the disease. The infrahyoid muscles are peeled off and preserved or in advanced cases removed on the same side as the thyroid. The trachea is divided and the œsophagus exposed and cut across. The œsophagus and hypopharynx are separated from the prevertebral muscles and fascia and the pharynx incised above the level of the hyoid bone. The magnitude of the operation varies a little with the extent of the disease but such variations affect only the removal of the lymphnodes, the thyroid and infrahyoid muscles; it should not affect the extent of the removal of the pharynx and larynx.

Reconstruction

This can be carried out in two stages or one. The two stage operation has been practiced for many years and was rationalized by Wilfrid Trotter in 1913. All two stage operations leave a temporary gap in the newly constructed pharynx and feeding is by means of a tube passed either directly into the pharyngostome or

through the nose A polythene tube is preferable to a rubber one as it causes less irritation of the tissues and is better tolerated even for very prolonged periods

Wookey's operation is based on that of Trotter it permits however a wider excision as it includes the larynx The size of the flap is greater but even so it is limited and the reconstruction depends upon the size of the skin flap The flap is laid on the prevertebral fascia and forms the posterior wall of the new pharynx It is secured in position by stitches and should lie without tension The upper end of the skin flap is joined to the posterior cut edge of the pharynx the flap is then turned on itself and the sutures continued on the anterior cut edge of the pharynx Similarly the œsophagus is joined to the lower part of the flap There is thus formed a full thickness skin funnel joining the oropharynx to the œsophagus This funnel is open along its lateral border The raw surface on the opposite side of the wound is covered by a free skin graft The cut end of the trachea is sutured to the skin above the sternal notch The second stage is undertaken four to six weeks later and consists in the closure of the pharyngostome The original flap may slough at its free edge and the second stage may thus be delayed If the loss of skin is considerable, only the posterior wall of the new pharynx is thus formed In such cases the anterior wall can be constructed from tube pedicles raised from the chest wall The tube pedicle method necessitates multiple operations and it usually takes many months before final closure is achieved (Fig 12) The final result is satisfactory and stenosis of the new pharynx is exceptional should this occur it lends itself to periodical and gradual dilatation

One Stage Reconstruction

Immediate reconstruction offers many advantages Primary repair of the pharynx enables the patient to swallow normally within a few weeks and obviates the need of multiple stage operations The method was devised by C G Rob and modified by V Negus It consists in the use of a large polythene tube used as a temporary carrier around which is wrapped a split skin graft taken from the thigh The original skin flap is used to close the wound and healing by first intention is obtained This method is to date the greatest advance in the surgical treatment of pharyngeal cancer It is very promising and should be applicable to a larger number of cases It is still in the experimental stage and will need gradual modification with increased experience Its most serious drawback at present is the tendency to stenosis which may be so great as to

preclude dilation and necessitate a gastrostomy Nevertheless, it is at present the most promising method

Technique of Primary Repair

Negus has designed a wide bore polythene tube oval in cross section expanded into a funnel at its upper end and a round collar shaped lower end A split skin graft taken from the thigh is



Fig 13 Radiograph of neck showing a Negus type of plastic tube on which the skin graft has been placed Within is a small polythene tube for feeding The black dots show the attachment to the skin of metal clips on stitches passing through the skin and the tube from one side of the neck to the other to maintain the tube in position



Fig 14 Barium swallow after total laryngo pharyngectomy and immediate one stage reconstruction showing the length of new pharynx made out of a Thiersch graft The Negus tube has been removed Tracheotomy tube shown

wrapped round the tube with the raw surface outwards (Fig 13) The tube is inserted into the œsophagus to which it is sutured with catgut sutures Similarly the upper funnel shaped end which lies at the level of the vallecula is sutured to the pharynx A smaller polythene tube is passed through the nose into the large tube and down the œsophagus this tube is used for feeding Saliva can be swallowed and passes down the main tube The original Z shaped skin flaps cover the skin graft and tube To prevent displacement



A



B

Fig 15 Laryngo pharyngectomy for post cricoid carcinoma one stage reconstruction by means of a skin graft on a Negus tube The patients illustrated in Figs 11 12 13 14 15 have been operated on by the author and the plastic repair was done by Mr J P Reidy F R C S

of the tube two or three nylon or fine wire stitches are inserted through the skin and through the tube and serve to anchor the tube in position The period of time the large polythene tube is left in position varies according to individual taste They can be removed (through the mouth) as early as the second week but have been left *in situ* for several months The method lends itself to many variations in detail The patient is fed through the inner small tube but is allowed to swallow water at the end of a week Primary healing is aimed at and is achieved in most cases (Figs 14 and 15)

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CHAPTER VI

THE ŒSOPHAGUS

HAROLD C EDWARDS

CONGENITAL ATRESIA

THE pioneer work of Haight (1944) and of Ladd (1944) in the U S A , and of Franklin (1947) in this country, has led to a much better prospect of survival for the infant born with atresia of the œsophagus Thus Potts (1950) records seven successes in twenty patients operated upon and Belsey and Donnison (1950) five survivors out of ten Haight (1953) summarizes his experience as follows since 1939 144 cases of œsophageal atresia have been seen most of whom have had tracheo œsophageal fistula Nine of the patients were not operated on because their condition did not warrant operation seven of which were prior to 1947, and only two since January 1st 1947 There were 72 operative recoveries Nine of the patients who recovered from operation have subsequently died from causes typical to the operation or more frequently from causes apart from the operation These nine cases all died subsequent to their original discharge from the hospital Sixty three of these have been treated by œsophageal anastomosis, nine by the multiple stage plan (and their two stomas had not as then been connected), and one by primary œsophagogastrostomy

The above results include all patients operated on including those during the developmental period of the operation Recent figures show a recovery rate in the vicinity of 60 per cent

To secure a still better proportion of successes, two things are necessary The first is that all those concerned with the care of the newborn including midwives should be well acquainted with the earliest signs of the anomaly and the second is that all surgeons associated with pediatric departments should be thoroughly versed both in the means of diagnosis and the technique of the operative treatment for success depends above all things upon immediate action

Incidence and Types

The incidence of atresia is probably greater than Franklin s original estimate of one in 2 500 births, and probably approximates

more closely to the estimate given by Belsey and Donnison of 1 in 800

Vogt's well known classification (1929) of the variations in the anomaly is still acknowledged and may here be quoted —

Type 1 Complete absence of the œsophagus

Type 2 Atresia of the œsophagus with both upper and lower segments ending blindly

Type 3 (*a*) Atresia of the œsophagus with a fistula between the *upper* œsophageal segment and the trachea

(*b*) Atresia of the œsophagus with a fistula between the *lower* œsophageal segment and the trachea

(*c*) Atresia of the œsophagus with a fistula between the trachea and *both* segments of the œsophagus

Of these types 3 (*b*) is easily the most common (32 of 35 cases Potts (1950)) with Type 2 a distant second in order of frequency of incidence All other forms are very rare

Diagnosis

Death from pneumonia is the inevitable fate of the untreated case and is also the main cause of fatality in those submitted to operation It is therefore of the greatest importance that diagnosis should be made before pneumonia has developed and before in fact any attempt at feeding by mouth has been attempted Diagnosis should ideally be made before the onset of the classical signs of choking attacks with cyanosis and dyspnœa during attempts to feed

In the commonest form of the deformity (Type 3 (*b*)) the symptoms depend upon the passage of mucus and gastric secretion from the lower œsophagus into the trachea and spill over of mucus from the œsophageal pouch and conversely the entrance of an excessive amount of air into the stomach The first signs may therefore be the appearance of frothy mucus within twenty four hours of birth perhaps tinged with bile and a significant distension of the abdomen These findings should be followed at once by testing the patency of the œsophagus by the passage of a medium sized adult rubber catheter If the passage of this be arrested aspiration should be carried out and the character and quantity of any result there may be noted Diagnosis is then confirmed by introducing ½–2 ml of iodized oil through the catheter and X raying the mediastinum An egg shaped cavity will be revealed (Fig 16) Radiology will also usually reveal an excessive amount of air in the stomach and intestine though the absence of this feature does not eliminate the possibility of the existence of a tracheal

fistula for as Donnelly (1950) has pointed out, the opening from the trachea into the œsophagus may be valvular

In Type 2 (atresia with two blind œsophageal ends) the significant radiological finding is complete absence of any gastro intestinal gas

Belsey and Donnison (1950) believe that respiratory distress due



FIG 16 X ray appearance of blind œsophageal pouch from a baby with a congenital tracheal fistula (Case referred by Dr Wilfrid Sheldon)

to atelectasis which for reasons unknown is commonly associated with atresia should itself lead to the attempted passage of an œsophageal catheter

Treatment

Immediately the diagnosis is made penicillin therapy is started the pouch kept empty by intermittent suction through a catheter and preparations for operation made Delay in operation

is only permissible in those in whom there has been delay in diagnosis and who in consequence may be dehydrated, and in whom pneumonia may already be present For them a period of twelve hours or so may be devoted to improving the condition by a transfusion of 30 to 40 ml of fresh blood and to await the beneficial action of the penicillin

Operation

If the assistance of an anæsthetist skilled in the art of anæsthesia in infants is not available open ether associated with local anæsthesia is the method best adopted If the choice is free exposure should be made through the right side of the chest Haight (1944) recommends an approach through the left side if the left lung is impaired so as not to embarrass the healthy right lung Extrapleural *versus* transpleural exposure of the œsophagus has been a subject of debate for some years but the general trend now seems to be in favour of the transpleural approach which unquestionably gives a much better access is easier to perform, and is not followed by any undesirable consequences

The pleural cavity is entered either through an intercostal incision or after subperiosteal resection of the fifth rib If the approach is from the right the azygos vein must be divided between ligatures if from the left the aorta must be mobilized and retracted after dividing between ligatures the first two or three intercostal arteries The upper pouch is sought in the areolar tissue behind the trachea its discovery being facilitated by the passage by the anæsthetist of a small rubber catheter through the patient's nose The pouch is freed gently from its bed but stripping should be cautious otherwise vitality of its wall may be jeopardized Should cyanosis be observed the cyanotic area should be cut away until bleeding is seen from the cut edge (Belsey and Donnison) The lower segment is then looked for and unless very short is found without difficulty If the approach is from the right side the vagus will act as a guide to it It is freed from surrounding connective tissue and its attachment to the trachea is defined A small curved clamp is placed across the fistula two guide sutures are passed through the wall of the œsophagus and the latter cut free from the trachea The fistula is closed over the clamp by two or three interrupted stitches and pulled tight as the clamp is removed The two œsophageal ends can now be brought together although there will be some tension owing to the tendency of the longitudinal muscle, particularly that of the lower segment to contract and widen the gap

An opening is made into the upper pouch at a point just posterior

to its centre. A No. 8 French soft catheter, with the trumpet end removed, is passed upwards through the opening into the mouth where it is grasped and held by the anaesthetist; the other end of the catheter is passed down the distal portion of the œsophagus into the stomach.

A single layer anastomosis is now made with closely placed interrupted sutures of fine silk mounted in eyeless needles, and after completion the catheter is withdrawn, and the chest closed, after re-expansion of the lung, without drainage.

After operation the baby should be nursed in an oxygen tent, and an intravenous infusion of 50-100 ml. of fresh blood given. Sudden and dangerous attacks of cyanosis may occur and will demand immediate aspiration of the pharynx. Feeding by mouth starting with 10 per cent. dextrose in water may be instituted in twenty-four hours and with a suitably diluted milk preparation in forty-eight hours.

The deformity in Type 2 varies in extent from a thin membrane to a gap of some inches or even absence altogether of the lower segment. When it has been found impossible to anastomose the two ends the following procedure has been adopted. The upper segment is brought out through the left side of the neck immediately above the clavicle to form an œsophagostomy and the lower segment brought down into the abdomen and through the abdominal wall to form a gastrostomy. If the child survives and eventually thrives one of the various methods of fashioning a new œsophagus is undertaken.

CARDIOSPASM

Consequent upon the perfection of the technique of trans-thoracic exposure of the lower œsophagus and cardiac end of the stomach, the old principle of œsophago-gastrostomy for cardiospasm, formerly performed through the abdomen, has experienced a revival only to illustrate again its shortcomings and to result in recession into oblivion. Barrett and Franklin (1949) have recorded their experience with nineteen patients upon whom this operation was performed. The marked benefits the operation conferred during the first six months or so following operation flattered only to deceive. Nearly all of them developed symptoms after this short respite, usually due to œsophagitis. The same authors treated six other patients by dividing the cardia through all coats in a longitudinal direction and suturing the resulting incision transversely with equally unsatisfactory results.

These experiences together with those of other surgeons serve to vindicate anew the claim of Heller's operation as the one of choice. But in order to secure the best results Heller's operation should be done at an early date, i.e. if permanent relief of symptoms is not obtained after two to three attempts to cure by means of a Negus hydrostatic dilator. Heller's operation can readily be performed through the abdomen if the same exposure of the cardia is made as for vagotomy. Some surgeons have noted in making the œsophageal incision an encircling fibrotic band in the submucosa and have expressed the opinion that the existence of such a band may be a causal factor.

Mega œsophagus

The development of a dilated and often tortuous œsophagus (mega œsophagus) may be a very insidious process and the patient may not for some years complain of symptoms sufficiently marked for him to seek medical advice. Sooner or later, however, œsophagitis will probably supervene and relief from the symptoms is sought. Alternatively it may follow cardiospasm for which conservative treatment has been continued overlong, or failure of Heller's or other types of operation. In some such cases, as Puppell (1950) has shown, œsophageal motility may be impaired or lost. There is some reason to believe that this dystonia may be the cause rather than the result of mega œsophagus. No local operation at the cardia is likely permanently to relieve this condition and consideration in cases in whom symptoms are severe and persistent should be given to the operation suggested by Delovers (1950) and by Wangensteen (1951) in which the lower end of the œsophagus and the proximal end of the stomach as far as the pyloric antrum are resected with end to end suture of the œsophagus to the residual stomach. As both vagus nerves are divided Wangensteen recommends that after the anastomosis an extra mucosal pyloroplasty should be performed to anticipate subsequent hold up at the pylorus.

CARCINOMA OF THE ŒSOPHAGUS

It is becoming more than ever clear that cancer of the terminal œsophagus and proximal stomach and cancer of the mid and upper œsophagus are attended by such distinctive individual problems that they should be considered as separate clinical entities. The treatment of the former by radical or palliative surgery constitutes a very great advance upon the now obsolete method of treatment by gastrostomy and irradiation. The results of surgery for

cancer in the upper œsophagus are however, despite notable advances in technique so disappointing that many will be prepared to accept the view of Scandinavian workers that, for cancer in this situation, œsophagectomy cannot compete with radiation therapy and intubation as a means of affording greatest relief to the largest number of patients (Pack 1948)

Santy and Michaud s (1951) study of 300 patients with cancer of the œsophagus seen during the preceding three years gives an illuminating picture of the present position as experienced at a famous continental clinic and should be studied in the original In 148 patients even exploratory operation was contra indicated, in 25 inoperability was revealed at operation One hundred and seventy nine were explored by thoracotomy Of these, 105 could not be resected and were treated by a palliative operation Resection was performed on the remaining 74 Fifty one had a carcinoma of the lower third and the operative mortality was 31 per cent 15 had a carcinoma of the middle third and the operative mortality was 60 per cent and in 5 the growth was cervical, 2 patients surviving operation

Cancer of the Terminal Œsophagus and at the Cardia

Burgess and others (1951) after an investigation of post mortem findings of 88 patients who had died with carcinoma of the œsophagus noted (*a*) that in at least half the specimens the lesions extended at least 1 cm in the wall of the œsophagus above the visible tumour In a few instances this intramural spread extended for 2 to 4 cm (*b*) That both squamous celled carcinomas and adenocarcinomas affecting the lower 8 cm of the œsophagus freely metastasized to lymph nodes below the diaphragm There was no significant difference in behaviour in this regard between the two types

The aim of the radical operation irrespective of preoperative biopsy findings should therefore be section of the œsophagus well above the visible growth and removal of the gastric lymphatic field This entails including the spleen and the tail of the pancreas among the parts removed a point stressed by Allison (1951) There is some doubt as to whether the whole stomach should be removed followed by œsophago jejunostomy or only the proximal two thirds or so followed by œsophago gastrostomy (Fig 17) Certain disadvantages are inherent in both methods (see page 82)

Approach The approach should be through an abdomino thoracic incision removing the eighth or ninth rib as far back as its angle The abdominal incision should cross the mid line, so that the left

rectus is completely divided. There is no advantage whatsoever in attempting to do this operation through an incision confined to the chest or through one in which the thoracic incision is skimped. The essence of success in this difficult procedure is wide exposure which can only be obtained through a lengthy incision. The immediate danger to the patient is not increased thereby but his prospect of survival is enhanced. It is not necessary to perform

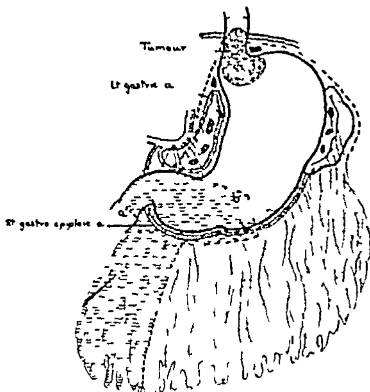


FIG 17 Operation for carcinoma at the cardia. Choice lies between total and sub total gastrectomy. Diagram to show extent of removal in either operation.
(After Dr J W Kelly, [illegible])

a preliminary laparotomy before opening the chest to determine operability for if the growth is too advanced for radical surgery it should be short circuited either by a gastro œsophagostomy or a jejuno œsophagostomy for which the same exposure is needed as for resection.

Reconstruction If the proximal half of the stomach only is removed the choice lies between implanting the residual œsophagus into either the stomach or the jejunum.

The former is easier in accomplishment but has certain dis

advantages, the chief among them being the danger of reflux œsophagitis As both vagi are cut there may also be some danger of the development of delay in emptying of the residual stomach Brain (1953) is of the opinion that gastro œsophagostomy may lead to dilatation of the œsophagus if the pylorus is still *permitted to* function

The alternative of œsophago jejunostomy has however, also marked disadvantages for it is more likely to be followed by severe malnutrition and by persistent diarrhœa complications which, of course have to be accepted if the condition necessitates total gastrectomy

Œsophago-jejunostomy The success of operation depends on an

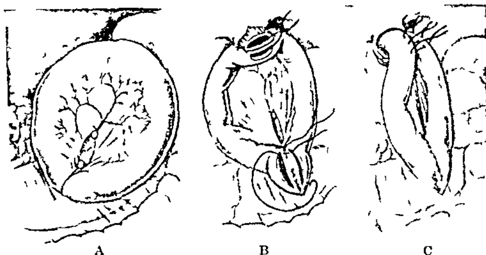


Fig 18 Œsophago jejunostomy showing Sweet s method of increasing the mobility of the jejunal loop (A) jejuno jejuno stomy (B) and Roscoe Graham s manœuvre designed to obtain greater security at the œsophago jejunal anastomosis (C)

efficient anastomosis more than on any other single factor The choice lies between an end to end anastomosis to a jejunal limb and end to side to a jejunal loop

Anastomosis of a limb of jejunum is the more attractive technical procedure but the safety of the anastomosis is jeopardized by two factors —its nakedness and the reduced vitality of the jejunum End to side anastomosis to a loop is far more secure Difficulty may be met in bringing a loop to the œsophagus without tension Usually this can be overcome by Sweet s manœuvre—division of one *of the main* vascular bundles of the loop near its origin from the superior mesenteric vessels (Fig 18A)

The posterior aspect of the suture line may be sealed off by suturing the jejunum to the parietal pleura The anterior line may

be guarded by rolling over the proximal limb of the loop, as suggested by Roscoe Graham (1945) (Fig. 18 C) In all cases a jejuno jejunostomy must be performed to preserve the anastomosis from the duodenal and pancreatic secretions This step will greatly enhance the probability of spontaneous healing should a fistula occur Although the mortality of the operation is still high—probably in most clinics in the region of 50 per cent —a number of four and five year survivals are recorded Franklin and Shipman (1952) have six patients living between two and four years Allison (1953) has one eight year and eleven five year survivals and Tanner (1953) five five year survivals Sweet (1952) has recorded the surprisingly low operative mortality of 11 6 per cent with a 17 5 per cent five year survival rate of those who recovered from operation

Judged from the standpoint of long term survival alone there may be cause for discouragement but if the palliative virtue of the operation be also taken into consideration it may be claimed that the surgery of cancer at this site has made a notable, if not a triumphant advance within the last decade

For the benefit of those who may doubt this contention the figures of Dickison (1951) may be quoted Between 1935 and 1948 55 of a total of 103 patients with œsophageal carcinoma had a palliative gastrostomy Twenty three (42 per cent) died in hospital after an average survival of twenty three days Of 27 who left the hospital alive the average survival time was a little over seven months It should be added that for this period the patient suffered the discomfort of a gastrostomy and that the pleasure of feeding by mouth was denied to him

Palliation The best palliative for the unresectable growth is either an œsophago gastrostomy or an œsophago jejunostomy the latter being indicated for infiltrating carcinoma at the cardia which will prevent freeing the stomach sufficiently to bring it up into the chest to a point above the growth If an œsophago jejunostomy is contemplated, the Roux operation takes precedence over the loop operation for it will generally be found impossible to bring a loop up to a sufficient height with the stomach *in situ*

The operation is analogous in its effect to gastroenterostomy for inoperable carcinoma obstructing the pylorus though it is a far more extensive procedure and the mortality very much higher

Cancer of the Mid and Upper Œsophagus

The role and scope of surgery for cancer within the vicinity of the aortic arch must still be regarded as ill defined and as yet unsatisfactory for the following reasons —

1 Eradication of any extra œsophageal spread, and of the immediate lymphatic field are impossible

2 The mortality of radical excision is, in most hands, excessive

3 To bring the stomach up to the œsophagus above the level of the aortic arch leaves the survivor with a complete mediastinal stomach, which is not compatible with any reasonable degree of comfort

4 Palliation by high gastro œsophagostomy if the growth is found at exploration to be ' unresectable ' cannot be compared from the patient's standpoint, with the results of intubation by a Souttar s tube

In an effort to surmount these problems there is an increasing tendency to use a right as opposed to a left thoracotomy, as originally recommended by Lewis (1946) , and a return to extra mediastinal œsophagoplasty both as a palliative and as a replace ment after total œsophagectomy

Right Thoracotomy The great disadvantage of operation through a right thoracotomy is that it necessitates two separate incisions—abdominal and thoracic Its great advantage over left thoracotomy is that the growth is far more easily removed from the right side, because the surgeon is not embarrassed during this approach by the aorta Increasing experience and improved pre operative care have enabled the operation to be undertaken in one stage, instead of the two stage procedure practised by Lewis in his early cases The stomach is first mobilized through a mid line incision and the œsophagus freed by blunt dissection as far into the chest as possible after division of the peritoneum surrounding the hiatus The abdomen is closed and the patient turned on to the left side (or on to the front—Sellors, 1952) The chest is entered through a long incision in the 7th intercostal space or after resection of the 7th or 8th rib The azygos vein lies in the pathway to the growth and is divided between ligatures After mobilization of the growth by sharp dissection the stomach is pulled up into the chest through the right crus The œsophagus with a wedge of cardia is now severed, and the resulting opening in the stomach closed An œsophago gastrostomy is then commenced well above the growth and the œsophagus removed after the posterior layers of the anastomosis are completed

Criticism has been levelled against the right sided operation on the grounds that after completion of the abdominal part of the operation, thoracotomy may disclose that the growth is inoperable Mathewson and Cohn (1950) however insist that it is nearly always possible to remove the growth even though the cancer is not com

pletely eradicated from the chest and the operation can be continued as a palliative procedure

Extra mediastinal Œsophagoplasty D Allaines and Banzet (1950) draw attention to the trend in many clinics towards extra mediastinal œsophagostomy followed by total thoracic œsophagectomy for mid œsophageal cancer The great drawback to the method from a technical standpoint is the liability to the develop

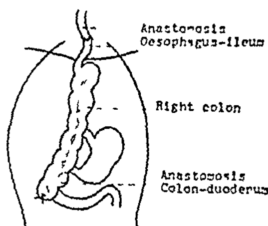


FIG 19 Subcutaneous œsophagoplasty using the right colon and terminal ileum

(By courtesy Dr L Lafargue and the Ed tor Bordeaux Chirurgical)

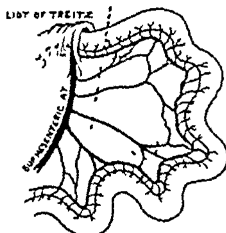


FIG 20 Preparation of jejunum for retro sternal œsophagoplasty Straight dotted line indicates sites for division of jejunum and vessels curved dotted lines for division of secondary branches if additional length is needed

(By courtesy Dr [illegible] Dalton and T [illegible] and the Editor Journal of Thoracic Surgery)

ment of a fistula at the anastomosis between the residual œsophagus (cervical) and the newly constructed œsophagus

Lefargue and his colleagues (1951) perform a pre sternal operation using the right half of the colon and the terminal ileum the latter being anastomosed to the œsophagus in the neck and the former to the duodenum (Fig 19) The first stage in the operation is a median laparotomy at which the xiphisternum is removed The right colon is freed as for a hemicolectomy after detaching the omentum from it The ileum is divided 6–8 in from the cæcum and the blood supply from the arcade is preserved the ileocolic artery being ligatured near its origin The transverse colon is then divided near its centre, and both ends closed An ileo colostomy is then per

formed The end of the colon is now implanted either into the stomach, duodenum, or upper jejunum, the last named being preferred A subcutaneous tunnel is prepared between the sternum and the skin in the direction of the left clavicle, and the abdomen closed The terminal ileum is brought out into the neck and anastomosed to the cervical œsophagus after an interval of some days

Robertson and *Sarjeant* (1950) have developed a method in which



FIG 21 Retrosternal jejunal œsophagoplasty *Barium* swallow X ray five weeks after operation

(*By courtesy of Drs R Robertson and T P Sarjeant and the Editor Journal of Thoracic Surgery*)

a long limb of jejunum, prepared after the manner popularized by Yudin is brought up into the neck through a tunnel immediately behind the sternum The steps of the operation are briefly as follows —

A left paramedian incision is made, and a limb of jejunum prepared division being made just below the flexure (Fig 20) The length required is ascertained by measuring the distance between the thyroid cartilage and the ligament of Treitz

The anterior mediastinum is then entered from the abdomen and the diaphragm separated from the costal margin on either side for

2 inches *from* the mid line *Simultaneously* the lower *cervical* œsophagus is exposed by a surgeon working from above and divided the distal end being invaginated The anterior mediastinum is entered from above and a passage made by blunt dissection simultaneously from above and below keeping close to the sternum The limb of jejunum is carried up through the tunnel and anastomosed to the cervical œsophagus and at the same time the abdominal part of the *operation is completed by anastomosis in* Y of the divided jejunum A gastrostomy is made before closure The post operative result is illustrated by Fig 21

This method is particularly suited to patients with simple corrosive structures of the œsophagus differing from Yudin s operation in being intrathoracic and isoperistaltic The operation *is* also being applied to the treatment of mid œsophageal cancer the latter being removed through a right thoracotomy some three weeks or so after completion of the œsophagoplasty

It is as yet too early to assess the full value and application of these methods but they are bound to command attention and future developments will be awaited with interest

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CHAPTER VII

DIAPHRAGMATIC HERNIA

HAROLD C EDWARDS

The diaphragm is an integral part of the muscular envelope of the abdomen subject to the same stresses and strains and to the same slow despoiling of its integrity and function by the passage of years as the external abdominal parietes and similarly disposed to be the site of herniation of abdominal contents The diaphragm shares also with the abdominal wall liability to congenital herniation resulting from maldevelopment but here consideration will be given only to acquired herniation

The most vulnerable area in the diaphragm is at the œsophageal orifice and this bears comparison with that most vulnerable of areas in the external abdominal wall—the internal ring Both the œsophageal hiatus and the internal ring transmit structures and both rely upon the integrity of the musculature to guard against other abdominal structures being forced through the aperture by intra abdominal pressure The advance of years into middle age and beyond is associated with two predisposing causes of herniation —

(a) Degeneration—impairment in muscular power which affects alike the whole body musculature and the deposition of fat (multiple pregnancies play a big part here)

(b) The tendency to increasing strain upon the weakening wall of the abdomen by common disorders of middle age—persistent cough chronic constipation urinary obstruction in men

This progressive reciprocal action—the wearing out of muscular power and the increasing tendency to strains upon the abdominal wall explain why the liability to herniation increases with age Indeed it is probable that one only has to live long enough to acquire a hernia—either diaphragmatic or inguinal or both

Mechanism at the Hiatus

As with the internal inguinal ring the mechanism which safeguards the hiatus is not fully understood Allison (1952) to whom we owe so much for his elucidation of many of the problems asso

ciated with this region of the body, believes that competence of the cardia depends upon the intrinsic circular muscle fibres at the gastro œsophageal junction and the oblique angle of entry of the œsophagus into the stomach The sling of muscle formed by the right crus of the diaphragm suspends the lower end of the œsophagus, in very much the same way, according to Allison, as the pubo rectalis suspends the rectum (Fig 22) Allison stresses this factor very much in his technique for the repair of a hiatus hernia, the success of which depends, in his view, very largely upon the recon struction of this sling of muscle

Collis (1953), as a result of dissection upon cadavers of the musculature of the hiatus which show great variations in anatomy believes that the repair of the hernia should be undertaken per

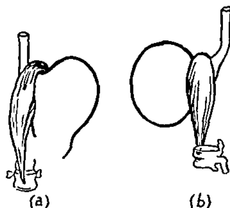


FIG 22 (*a*) The right crus of the diaphragm forming a sling for the œsophagogastric junc tion Anterior view (*b*) The sling of the right crus as seen from the side

(Figs 22–26 by courtesy Mr P R Allison and the Editor Surg Gynec Obstet)

abdomen except in the obese subject, for whom a thoraco abdo minal incision is advocated

The Cardia

Though we are ignorant of the exact mechanism at the cardia by which reflux into the œsophagus is normally prevented one thing appears certain—that this mechanism fails to work when the cardia comes to occupy a position in the thorax where it is subjected to an alien set of environmental forces Thus it is that in hiatal hernias in which the cardia is involved reflux of the gastric secre tions into the œsophagus is a common, if not a constant, sequel Like the small intestine, which so often suffers after gastro entero stomy the œsophagus has little defence in its make up against the irritating and sometimes erosive activity of the gastric juice and persistent though intermittent bathing of its unprotected wall in this medium leads to œsophagitis The degree of damage will vary from a mild œsophagitis to a severe inflammation extending high up into the œsophagus, and on occasion to the development of a typical

peptic ulcer subject to the characteristic complications of bleeding perforation and deformity It is probable that the magnitude of the damage the gastric juice will do is directly proportional to its degree of acid and enzyme potential though Allison is of the opinion that œsophagitis is not necessarily due to the acid component but may be caused by enzymatic action

Hiatus Hernia

Hiatus hernia is easily the commonest non malignant disorder of the gastro œsophageal junction There are two distinct types of herniation—the sliding hernia in which the cardia moves up into the thorax and the para œsophageal in which the cardia remains in its normal situation and the fundus passes through the hiatus anterior to the œsophagus rolling at the expense of the greater curvature Occasionally a secondary para œsophageal hernia may complicate a sliding hernia The sliding type is easily

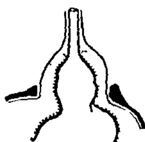


FIG 23 Diagram of the anatomical relations of sliding hiatus hernia Note the stretching of the peritoneal reflection and the phreno œsophageal ligament

the more common of the two Of 385 hiatus herniæ Allison (1951) *found 352 sliding and 33 para œsophageal or mixed*

Sliding Hernia The cardia is normally mobile the degree of mobility varying in different subjects and at different ages Under conditions of stress it may make an excursion into the thorax to return when normality is re established Thus in pregnancy displacement of the cardia into the thorax is a probable cause of the heartburn which is so frequently a symptom especially in the later stages In extreme flexion of the body in the stooping position especially if combined with rotation of the trunk radiology can demonstrate in the apparently normal a short excursion upwards of the cardia

Such a natural mobility will of course predispose to permanent herniation the cardia eventually becoming lodged in the thoracic cavity together with a portion of the stomach As with herniation elsewhere once the condition is established it is liable to be progressive

At first the length of the œsophagus is not altered, but in due course shortening will take place This shortening will become irremediable if the œsophageal wall becomes contracted by scar tissue due to œsophagitis or peptic ulceration

This secondary fixed shortening of the stomach due to scar tissue contraction is distinct from that rare condition of congenital short œsophagus, in which the shortening is the predisposing cause of the œsophagitis It is not, however, always possible to distinguish between the two in clinical practice Very rarely, the presence of heterotopic gastric epithelium in the wall of the œsophagus may be the initiating factor in ulceration followed by shortening and herniation The symptoms associated with sliding hernia are usually mild in degree, due to the presence of the stomach in the thorax and consist of intermittent attacks of epigastric discomfort with a sense of fullness and belching after meals simulating closely the symptoms of chronic cholecystitis The more

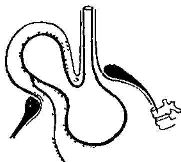


FIG 24 Anterior wall of the stomach rolled up into the sac to form a para œsophageal hernia

serious symptoms are due to reflux of gastric juice At first this will cause heartburn and eructations, particularly at night when the patient is recumbent The severity will increase with the degree of œsophagitis and if a gastric ulcer arises pain and dysphagia may be extreme Hypochromic anæmia is a frequent association

Para Œsophageal Hernia The body of the stomach passes through the hiatus in front of the cardia which (unless the hernia is a development secondary to a sliding hernia) remains *in situ* The amount of stomach which passes through is variable Though this is usually limited to the fundus the tendency is always towards increase in size The stomach rotates at the expense of the greater curvature so that it comes to lie upside down in the thorax (Fig 24) Rarely the whole stomach may be permanently lodged in the chest and occasionally a portion of the transverse colon Reflux of gastric contents into the œsophagus does not occur in para œsophageal hernia so that it does not become complicated as does the sliding hernia by œsophagitis, ulceration

or shortening of the œsophagus The symptoms caused are due to the presence of the stomach or part of it, within the thorax, and their degree of severity will depend upon the size of the hernia and the degree of constriction at the neck of the hernia The main features are recurrent fullness after meals, eructations of wind, tightness in the chest shortness of breath retrosternal pains, like cardiac pains anæmia from gastric erosions due to congestion, and very occasionally strangulation of the intrathoracic portion of the stomach The symptoms may simulate most of those caused by the more common upper abdominal lesions any of which may co exist and may also closely simulate those of coronary disease

Diagnosis

The diagnosis of both types of hernia can be made radiologically although the distinction between the two by radiological means alone is not always possible (Johnstone, 1951)

Treatment

Sliding Hernia In mild cases of heartburn and dyspepsia associated with a small sliding hernia relief can be obtained from alkalis and sleeping in a propped up position In the more severe cases operation with reduction of the hernia removal of the sac, and narrowing of the hiatus by sewing together the crura behind the œsophagus may be performed either through the abdomen or the chest according to the individual preference of the surgeon

When the hernia is of large size and associated with fixed shortening of the œsophagus due to scarring resulting from reflux œsophagitis the problem of cure is a complex one for the shortening of the œsophagus will prevent reduction of the cardia Excision of the lower end of the œsophagus and the herniated portion of the stomach with œsophago gastrostomy is likely to be followed by a recurrence of reflux œsophagitis or ulcer The operation of choice is to resect the diseased area of the œsophagus and replace the stomach after turning in and oversewing the cardia into the abdomen The jejunum is then divided 2 to 3 inches below the ligament of Treitz the distal segment brought up to the œsophagus and an end to end anastomosis made between the two The proximal end of the jejunum is then implanted end to side into the segment brought up to the œsophagus As both vagus nerves are divided it is expedient to perform an extra mucosal pyloroplasty to ensure that the stomach will empty

Para Œsophageal Hernia Operative reduction of a para œso phageal hernia should normally be undertaken if the symptoms are

severe Harrington (1948) suggests that the operation will certainly be required if one third of the stomach or more has entered the thorax In the rare event of the presence of part of the transverse colon in the sac operation should not be delayed because of the danger of strangulation In the old and infirm who are unlikely to withstand the radical operation considerable if not complete relief from symptoms can be obtained by division of the left phrenic nerve This by paralysing the left diaphragm causes relaxation of the muscular wall of the orifice thus reducing the danger of constriction of the stomach at the neck of the hernia It is tantamount to paralysing the internal oblique muscle of the abdomen in irreducible inguinal hernia

Operative Approach

Though many surgeons including Harrington (1948) and Collis (1953) prefer the abdominal route the weight of evidence seems

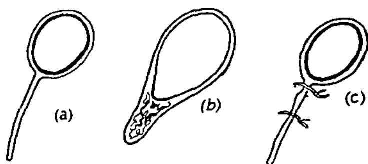
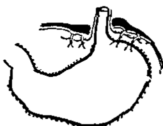


FIG 25 (*a*) Diagrammatic representation of the right crus of the diaphragm split to form the œsophageal hiatus (*b*) Represents the further splitting of the crus when a hiatus hernia occurs (*c*) Restoration of the hiatus by light suturing of crural fibres behind the œsophagus

FIG 26 The normal fascial and peritoneal reflection at the diaphragmatic hiatus The fascia on the deep surface of the diaphragm is reflected on to the œsophagus as the phreno œsophageal ligament and fascia propria Vessels and lymphatics lie between this and peritoneal reflection



to point to the transthoracic approach (made after resection of the eighth rib) as the method of choice for most cases Exposure of the hiatus is better and enables greater precision in operating Allison stresses the great importance in the repair of sliding hernia of

clearing the muscle fibres from the right crus, which sweep round to the left to form the posterior boundary of the hiatus—fibres which are displaced by the hernia and which should be incorporated in the repair if a functional hiatus is to be reconstituted , this can be more easily accomplished from above (Figs 25 and 26) Other points are that the phrenic nerve may be temporarily blocked with novocaine to facilitate diaphragmatic repair and finally, should there be any adhesions between the stomach and the hernial sac they are more readily appreciated and divided Boyd and Classen (1951), who have used both approaches for different cases extensively, are of the opinion that the recurrence rate morbidity, and mortality are less when the thoracic route is used and O Neill (1951), who used the abdominal and thoracic routes almost equally in fifty five cases showed his recurrence rate following the abdominal route to be 27 per cent and the mortality 6 5 per cent as opposed to 8 per cent and 8 per cent respectively for the thoracic route

Peptic Ulcer of the Œsophagus

Primary peptic ulcer of the œsophagus may rarely develop in the lower œsophagus—primary in the sense that it is not caused by reflux due to acquired deficiency of the cardiac mechanism such as occurs in sliding hernia and of course after œsophago gastrostomy Formerly it was thought that islands of ectopic gastric mucosa lying in the œsophagus might be responsible for such ulceration and Barrett (1950) in his masterly review of the problem elaborates the view that the cause lies in the fact that typical gastric epithelium may line the œsophagus for a variable distance extending even into the cervical œsophagus perhaps and in unbroken continuity with that of the stomach itself There is present in effect a mediastinal stomach the œsophagus ending from the mucosal viewpoint where its stratified epithelium ends Most of such cases Barrett thinks are in truth examples of congenital short œsophagus

The treatment for primary peptic ulceration is to dilate the associated narrowing at œsophagoscopy and to attempt to maintain a normal œsophageal calibre by daily passage thereafter of a mercury bougie As there is no dependable surgical cure available operation should be considered only for those in whom the condition proves completely intractable Simple excision of the lower end of the œsophagus followed by gastro œsophagostomy is likely to fail because of the danger of recurrence due to reflux If it should be attempted, the anastomosis should be made at the level of the aorta for it is said that the œsophagus above this level is more resistant to reflux ulceration than it is below it (d Abrue 1953) Wangenstein (1949)

recommends subtotal gastrectomy to diminish acidity A further alternative is œsophago jejunostomy (see p 94)

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The Surgical Treatment of Gastric Ulcer

Conservative partial gastrectomy remains the operation of choice, and the indications for its application have not changed, except that in many clinics where the mortality of the operation

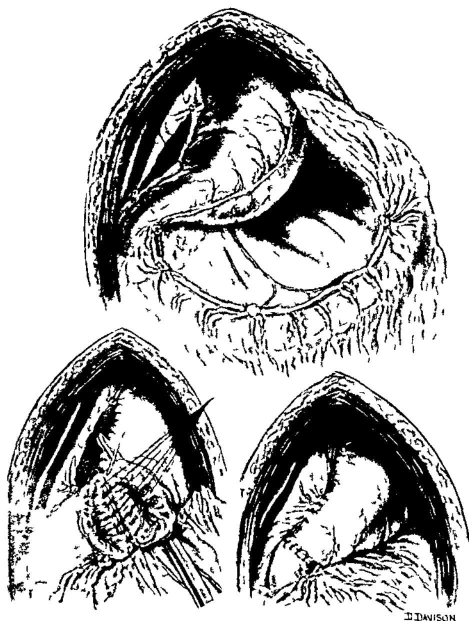


FIG 27 Billroth I operation (McEvedy) (*a*) Detachment of omenta (*b*) Gastro duodenostomy A single layer of interrupted sutures is used for the posterior walls (*c*) The completed operation

CHAPTER VIII

THE STOMACH AND DUODENUM

HAROLD C EDWARDS

SURGICAL TREATMENT OF PEPTIC ULCER

THE surgical treatment of *gastric* ulcer remains that of excision of the stomach from a point immediately above the ulcer, conserving as much of the stomach as is consistent with obtaining a satisfactory reconstruction The rationale of the surgical treatment of *duodenal* ulcer is to obtain a permanent reduction in the quantity of acid secretion

This difference in motif is based upon known differences in ætiology James and Pickering (1949) have recently drawn attention to the latter by a series of controlled estimations of the pH of the gastric contents under conditions as near as possible to normal All subjects upon whom the investigation was made received four meals during the day with milk at regular intervals between meals Samples of the contents of the stomach were obtained at half hour intervals during the day and at hourly intervals at night and their acidity determined by an electrometric method

(*a*) In duodenal ulceration the curves of intragastric acidity showed in general a higher level of acidity a less conspicuous neutralization after food and the maintenance of higher acidities at night after food had disappeared from the stomach

(*b*) In gastric ulcer the most striking deviation from normal in the curves of intragastric acidity was the fall to or near neutrality during that part of the night when food had left the stomach in 16 of 23 gastric ulcer patients There was evidence that neutralization of gastric contents after food had left the stomach was due to cessation of acid secretion

The conclusions were that the evidence was consistent with the hypothesis that *duodenal ulcer* is caused by the action of abnormal degrees of acidity over abnormally long periods of time but inconsistent with the hypothesis that *gastric ulcer* is due to this cause These observations confirm in fact that gastric and duodenal ulcers are diseases of different ætiology

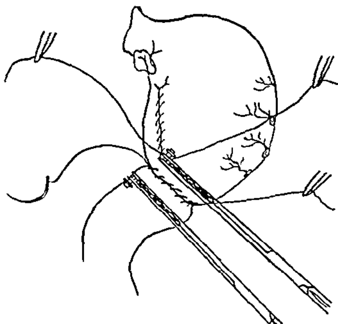


FIG 28 (c)

FIG 28 Lang Stevenson clamps for partial gastrectomy and their application to the Billroth I operation

(By courtesy of Mr Lang Stevenson and the Editor The Lancet)

has by dint of long practice become low, there is an increasing tendency to resect the stomach in acute perforation instead of limiting the operation to closure of the perforation

There is however a pronounced increase in popularity—or perhaps one should say return to favour—of the Billroth I type of reconstruction as opposed to the Billroth II The Billroth I type of reconstruction is a very simple matter to perform after partial gastrectomy in most cases of chronic gastric ulcer especially in women, and has the following advantages over the Billroth II operation —it is less disturbing to the patient it is more physiological in the sense that gastric contents enter the duodenum and not the jejunum it is claimed to be freer from post prandial disturbances

As the late Peter McEvedy showed a single layer of closely placed interrupted sutures is completely reliable for the posterior gastro duodenal suture line and this simplification in technique diminishes considerably the amount of duodenal wall needed for the anastomosis and reduces the risk of creating too narrow a stoma Fig 27 shows original drawings which McEvedy had prepared especially for publication here

Lang Stevenson (1951) has designed a set of clamps which in the author s opinion facilitates the operation (Fig 28 (a) (b) and (c)

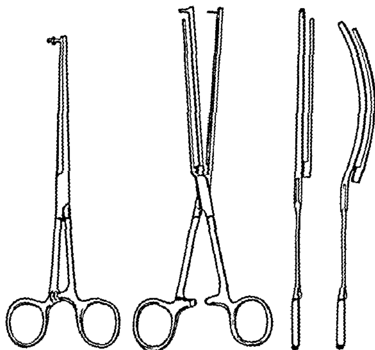


Fig 28 (a)

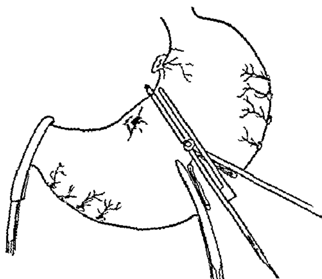


Fig 28 (b)

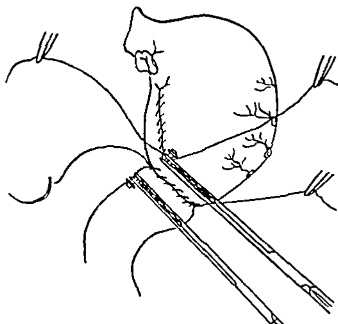


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The Surgical Treatment of Duodenal Ulcer

The object of surgery is to secure a permanent reduction of acid secretion to a level low enough to discourage further ulceration either recurrent or secondary (anastomotic) Gastro enterostomy was discarded because it failed to secure such a reduction and was replaced by wide resection which has achieved this objective Revulsion against performing so mutilating an operation upon patients especially young patients, in whom the ulceration though painful and intractable to medical treatment is small in degree led to the introduction early in the last decade of two alternative methods of obtaining a reduction in acidity These were ' physiological gastrectomy in which the stomach is deprived by multiple ligatures of most of its blood supply and vagotomy

Physiological gastrectomy made little appeal and has been largely discredited but vagotomy, either alone or in conjunction with a drainage operation such as gastro enterostomy remains in the field as a possible alternative procedure to resection

Partial Gastrectomy for Duodenal Ulcer

Most surgeons are in agreement that partial gastrectomy performed for the cure of duodenal ulcer should be of the Billroth II type Reconstruction after resection may be antecolic or retrocolic with or without a Lake Hoffmeister valve in either instance Though there is no reliable evidence that any one method is superior to all others the author s preference is for the retrocolic operation with fashioning of a valve Of greater importance is the question of the amount of stomach which should be removed The late Hedley Visick (1948) was of the opinion that both for gastric and duodenal ulcer the resection should be taken up as far as (but not including) the very first vasa brevia a procedure which he designated Measured Radical Gastrectomy (Fig 29) He performed this operation on 505 patients with a mortality in the last 430 of 3 7 per cent A careful follow up of between twelve years to six months showed no single case of recurrence or secondary ulceration and Visick contrasted this with a 5 3 per cent recurrence rate after one half to two thirds removal and 3 7 per cent recurrence rate after two thirds to three quarters removal

Pulvertaft (1952) who was associated with Visick in a further review concluded that the extent of resection (i e as between Visick s operation of M R G and the usual two thirds to three quarters gastrectomy) had only a slight effect upon the overall clinical result, and it is probable that the bulk of surgical opinion is

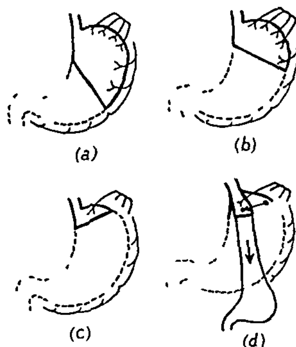


FIG 29 (*a*) Half to two thirds gastrectomy (*b*) Two thirds to three quarters gastrectomy (*c*) Measured radical gastrectomy (Visick) (*d*) Division of all but the first vasa brevia allows the stomach stump to lie vertically without being hampered by tethering (Visick)
(*By courtesy of the Editor The Lancet*)

in favour of the less radical operation i e removal up to or including the last vasa brevia

Modifications in the Technique of Partial Gastrectomy

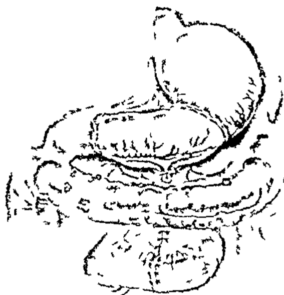
Billroth I Recently attempts have been made to compensate for the loss of the stomach by grafting a segment of jejunum (Henley 1952) or of transverse colon (Moroney 1953) between the gastric stump and the cut end of the duodenum after the stomach has been removed

Henley records having successfully performed his operation on thirty five occasions and for the following conditions gastric ulcer (13) removable duodenal ulcer (18) irremovable duodenal ulcer (4) perforation of peptic ulcer (4) remedial for post gastrectomy syndrome (4) and cancer (2) The immediate results of the procedure have been encouraging Twenty seven patients followed up for three months or longer gained an average of 14 lb after operation varying from a maximum of 28 lb to a minimum of 2 lb In all the general condition and appetite were improved and none suffered from dumping symptoms nor from bowel dysfunction (Fig 30)

Moroney (1953) has recorded the immediate results of 150 patients submitted to the operation of colon replacement for non malignant conditions together with a few total resections for cancer For the



(*a*)



(*b*)

FIG 30 (*a*) Replacement of removed portion of the stomach by a segment of the ileum (*b*) Operation completed

(By courtesy of Mr F A Henly and the Editor British Journal of Surgery)

non malignant conditions, which included 82 duodenal ulcers 11 duodenal and gastric ulcers and 27 gastric ulcers, the immediate post operative deaths amounted to a total of five (Fig 31) Moroney stresses that the abolition of hyperchlorhydria is an essential preliminary to colon replacement He has found from his experience that the extent and degree of post gastrectomy nutritional changes are markedly reduced, and that post gastrectomy symptoms of the vaso motor type are eliminated altogether In one patient the operation of colonic replacement was performed five years after

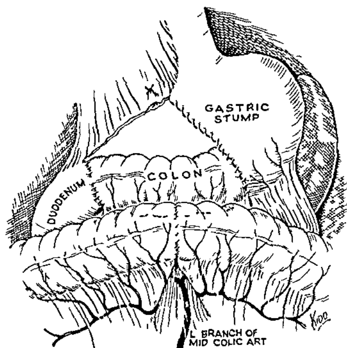


FIG 31 Replacement of the portion of the stomach removed by a segment of the transverse colon Moroney s operation (see text)
(By courtesy of Mr J Moroney and the Editor The Lancet)

gastrectomy, because of post gastrectomy marasmus This patient gained nearly 3 stones in weight within eighteen months of colon replacement

Both the Henley and the Moroney operations should be regarded as experimental until their worth is proven by a five year follow up

Billroth II Dailey and others (1952) recommend an antecolic gastro jejunostomy, attaching the jejunum to the whole length of the cut end of the stomach but making the anastomosis only with its middle third (Fig 32) They claim as a result freedom from any complication due to angulation of the jejunal limbs O Neill (1952)



Fig 32 Modification of the Billroth II—Polya gastric resection

practises a similar operation with intent to prevent too rapid emptying of the stomach and thus reducing liability to post gastrectomy symptoms

Vagotomy

Simple bilateral vagotomy can with a minimum of operative discomfort and with no risk to life secure relief from the symptoms of duodenal ulceration for many years—perhaps permanently When successful it has no peer amongst other measures either medical or surgical The trouble is that it is not successful often enough for a lot of patients who have undergone vagotomy develop distressing side effects which rob the operation of all virtue

Results in terms of percentages reported by different investigators show wide discrepancies Dragstedt and Woodward (1951) claim 83 per cent good results in 371 cases followed for seven years (in half the operation was combined with gastro enterostomy with only slightly better results) Pollock (1952) found that only 56 per cent of 658 cases followed for four years were satisfactory The Mayo Clinic figures lie somewhere between these extremes and in recording them Walters and Belding (1951) mention that the operation is becoming increasingly less popular because of the uncertainty of its outcome In the author s experience of 24 cases followed up for four to five years 9 have proved completely successful in every respect 8 were improved but 7 were failures It was observed that the best results were obtained in the excessively nervous type of patient in whom duodenal deformity due to scarring was only slight in degree

The main undesirable side effects of vagotomy are gastric stasis and diarrhœa In most cases gastric stasis is not of serious import but in a proportion—perhaps one third—of the patients there is obvious clinical evidence of retention of stomach contents the most embarrassing being that of foul eructations The retention is often associated with diarrhœa and is probably a contributory cause of

the latter for when it is relieved by a short circuit or pyloroplasty, the diarrhoea usually disappears In mild cases of gastric retention, the administration of urecholine (beta methylcholine chloride) is often beneficial

Pollock (1952) has confirmed the findings of other workers in observing a significant relation between the degree of acidity after vagotomy and the degree of retention, as illustrated in Table VI

TABLE VI — *Association of Negative Insulin Test Meal with Severe Gastric Retention*

Insulin Test meal	Severe Retention	No Severe Retention	Proportion as %
Negative	26	48	54
Weakly positive	19	59	32
Strongly positive	12	81	15

Diarrhoea apart from that associated with gastric retention is rarely severe though it may cause some alarm in the immediate post operative period even if vagotomy has been combined with gastro enterostomy Frequently the moderate degree of looseness of the bowels which may follow operation is regarded by the patient, previously constipated as a purposive achievement of the operation, and he is well satisfied with the new order

Early post prandial symptoms (dumping symptoms) may follow vagotomy as they do gastro enterostomy and partial gastrectomy but they are seldom severe Delayed post prandial symptoms—hypoglycaemia—are however, quite common but are not serious and readily disappear if a lump of sugar is taken

Other recorded sequels to vagotomy are the development of chronic gastric ulcer (Morrissey, 1950) and chronic hypertrophic gastritis Dysphagia is common during the first few days after operation only rarely does it persist In one of the author s cases however, a radiological appearance simulating a mild degree of cardiospasm was seen six weeks after operation

Recurrence after Vagotomy for Duodenal Ulcer

The recurrence rate of ulcer symptoms varies with different observers Moore (1948) investigated 116 cases of vagotomy for duodenal ulcer and noted 13 recurrences The essential feature of the recurrent case was a period of complete relief with healing of the duodenal ulcer followed after a long interval by reappearance

of the ulcer with mild or insignificant symptoms and restoration of a delayed secretory response to insulin In other words the effect of vagotomy wore off and vagal function became slowly re established In Pollock s (1952) series in which the strictest criteria of recurrence of ulcer were used it was shown to be under 4 per cent in 589 patients Pollock noted a definite relationship between incidence of recurrence and of positive responses after insulin test meals

Of 507 patients for whom vagotomy plus gastro enterostomy was performed recurrence of duodenal ulcer was noted only in two (less than 0 5 per cent) Evidence of jejunal ulceration was however, present in six

Vagotomy in Combination with other Surgical Procedures

Because of the high proportion of failures many surgeons have abandoned vagotomy as an instrument of treatment for duodenal ulcer others still recognize its worth in principle and seek to anticipate gastric retention by combining it with a drainage operation with a high degree of success

Vagotomy combined with either posterior gastro enterostomy—the stoma being placed near the pylorus or with pyloroplasty (Tanner 1950) or hemi pyloromyomectomy (Beattie 1950) give equally good immediate results Pollock records 88 per cent of satisfactory results after 507 cases of vagotomy and gastro enterostomy and 87 per cent of satisfactory results after 266 patients treated by vagotomy and either pyloroplasty or pylorectomy It must be noted however that these patients were followed up only for one to two years after operation

Nearly all published figures record the same high standard of results after vagotomy and gastro jejunostomy for duodenal ulcer In particular Orr and Johnson (1949) pioneers of vagotomy in this country speak highly of the cure rate over five years

More recently (1953) the latter have successfully practised three quarter gastrectomy with vagotomy for cases with an abnormally high degree of acidity hoping thereby to obtain the best of both worlds and the worst of neither One would need however to be persuaded that this procedure possessed solid advantages over the conservative operations before one accepted it in preference to the latter

The author has practised vagotomy combined with antrectomy and excision of the ulcer with excellent immediate results but is not as yet satisfied that this more complicated operation possesses any material advantage over vagotomy and gastro enter st

Choice of Treatment for Duodenal Ulcer, Partial Gastrectomy or Vagotomy and Gastro-enterostomy ?

A comparative study on an immense scale of vagotomy and gastric resection has recently (1952) been conducted by the National Committee on Peptic Ulcer of the American Gastro enterological Association In their report no less than 4 076 patients treated by vagotomy alone or in combination with other surgical procedures, and 1 163 treated by partial gastrectomy, have been analysed Two of the immediate problems for which the study was undertaken are stated to be —

(1) The question as to whether gastro enterostomy and gastric resection are better operations when combined with vagotomy

(2) The question as to whether gastro enterostomy supplemented by vagotomy is equal or superior to partial resection alone

The questions were answered thus —

(1) In these groups of cases of duodenal ulcer, partial resection alone when more than 70 per cent of the stomach is removed has produced results as good as those produced by partial resection plus vagotomy, with the possible exception of a higher incidence of histamine achlorhydria after the latter operation

(2) Partial resection alone is superior in its results to gastro enterostomy plus vagotomy under the conditions prevailing in the institutions which co operated in this study

These opinions should not however, be taken as the final word, nor would the committee wish them to be so taken In making his decision as to which operation to practise the surgeon will bear in mind the obvious advantages of preserving the stomach, the removal of which may result in serious nutritional deficiencies (page 117) This advantage is particularly to be observed in the younger patient and especially if he is engaged in arduous work After experience with both types of operation the author is of the opinion (*a*) that partial gastrectomy is the operation of choice for the older subject, in whom there is gross deformity of the duodenum and particularly if the ulcer is a penetrating one and (*b*) that vagotomy associated with a conservative operation such as gastro enterostomy or pyloroplasty is the operation of choice in the young subject, particularly if the duodenal deformity is not gross and the duodenum lies free It may be remembered in this connection that in the event of failure due to recurrent or secondary ulceration, the more radical procedure is still available

Vagotomy for Secondary (Stomal) Ulceration

For some, the only valid indication for vagotomy is for the relief of symptoms due to stomal ulcer following partial gastrectomy Of 36 cases recorded by Crile and Brown (1951) good results were obtained in 26 It is interesting to note that according to Alvarez (1948) vagotomy does not necessarily protect from marginal ulcerations

Pollock (1952) found that recurrences of ulceration appeared or were suspected in 12 of 74 patients with jejunal ulcer submitted to vagotomy In 4 the ulcer was duodenal, in 2 gastric and in 1 jejunal

The American Committee on Vagotomy paid especial attention *to the value of vagotomy in the treatment of gastro jejunal ulcera*tion and as to whether it was superior to resection The results of the examination of 99 cases of gastric resection and 294 cases of vagotomy alone led them to the conclusion that in the treatment of stomal ulcer following gastro enterostomy the results of resection were better than of vagotomy but that vagotomy alone was superior in the treatment of stomal ulcer following gastric resection

Summary

It is still too early to dogmatize upon the place of vagotomy in the treatment of peptic ulcer although it is generally agreed (*a*) that gastric ulcers should not be treated by vagotomy and (*b*) vagotomy is the treatment of choice in stomal ulceration, particularly if following partial gastrectomy

Of vagotomy in the treatment of duodenal ulcer it can be said that the immediate results in the treatment of the painful non obstructing ulcer are good but that it is followed by intractable gastric delay too frequently for it to be used as a routine and should therefore be normally accompanied by a drainage operation

PERFORATION

The surgeon has a choice among three methods of treatment of the perforated peptic ulcer each of which according to its advocates is superior to either of the other two They are (1) immediate operation and simple suture (2) immediate operation and partial gastrectomy (3) non operative or aspiration ' treatment

If one discounts the bias of enthusiasm for any one method it can be discerned that the immediate results judged in terms of survival alone are in the hands of the surgeon experienced in the method of his choice as nearly equal as to make argument profitless as to which is the best Thus Sangster (1948) is able to record 103

perforations treated by simple suture with only four deaths, Nuboer (1951) 131 perforations treated by immediate partial gastrectomy with five deaths, and Taylor (1951) 101 cases of non operative aspiration treatment with eleven deaths

The great improvement in the immediate results of operation is well illustrated by Sangster s figures—twenty four deaths in 100 cases recorded in 1939, and the 4 per cent of the series mentioned above, and by Chamberlain s (1951) massive series of 1,622 cases culled from the twenty year period 1930–49 in which the death rate (including cases too ill for operation) was 17 9 per cent as opposed to the 6 to 7 per cent of the last two years This improvement is due to better medical care—including earlier diagnosis, to the increased availability of skilled surgeons to advances in anæsthesia, and to the antibiotics

In deciding upon which method he shall adopt in practice, each individual surgeon will be guided by his own capability, and by the facilities he has at his disposal for after care For most, the operation of simple suture will find the greatest appeal, though it is true that the majority of those who survive this procedure will suffer a recurrence According to Turner (1951), the incidence of recurrence is in the neighbourhood of 85 per cent and he himself believes that all survivors should therefore be submitted to a radical operation within the immediate post operative period—that is to say, within three to four weeks after closure of the perforation

Immediate partial gastrectomy will—or should—save the patient from subsequent ulcer invalidism and in the hands of the experienced gastric surgeon may not be a more dangerous procedure than resection by the same surgeon for the non perforated case None theless, it would not be acceptable as a routine procedure to most surgeons particularly for the younger patient with a duodenal ulcer, in which perforation is preceded by a short history of ulcer symptoms

The great attraction of the aspiration method of treatment from the patient s standpoint is the avoidance of operation Moreover, it saves him from all risk due directly to the operation which, in Taylor's view accounts for half the mortality amongst those treated surgically As Heslop Bullough and Brun (1952) point out, and Stead (1951) agreed the method should however only be undertaken by those prepared and able to keep the patient under their close surveillance and it is not suited to circumstances where first class assistance and nursing facilities are not available Stead who records five deaths amongst fifty patients treated by aspiration (four of the deaths were in patients rated too ill to withstand opera

tion) believes it to be the treatment of choice He gives the indications for surgery as follows —

(1) Inexperience in the method
(2) Failure to improve
(3) Evidence of gross peritoneal contamination
(4) When the diagnosis is in doubt

The last named must be considered a serious bar to routine adoption of the method though Taylor rightly points out that inaccurate diagnosis is an equal handicap if routine laparotomy is favoured for here conditions such as coronary thrombosis and pancreatitis may suffer needless exploration

It has also been pointed out that perforation is not limited to peptic ulcer but may occasionally be due to carcinoma of the stomach

A useful contribution to the assessment of operation and aspiration is made by Beattie (1951) who made a trial of expectant treatment in 40 consecutive cases 32 were duodenal ulcers and one died 7 were gastric ulcers and four died and one was a carcinoma who also died As result of this experience Beattie has reverted to early laparotomy

Taylor has modified slightly the procedure he originally advocated The aspirating tube now used is opaque to X rays and radiological confirmation of its position in the stomach is obtained At the same time the amount of gas collection under the diaphragm is noted A second radiograph is taken after twelve hours and if an increase in the amount of accumulated gas is revealed operation is considered He prefers intermittent to continuous aspiration

BLEEDING FROM PEPTIC ULCERATION

NORMAN C TANNER

THE management of bleeding peptic ulceration has in the past been confused by opposition between the supporters of medical and surgical treatment Perhaps the most notable recent advance is the dissolution of these rivalries and an attempt to define the circumstances under which surgical intervention is required with particular attention to the type of ulceration the age and condition of the patient and the medical and surgical facilities available

The concept of a purely medical or non operative approach to the bleeding ulcer is ended for all agree that certain patients will die unless the bleeding vessel is dealt with surgically Similarly an almost purely surgical approach to the problem is certainly

inadvisable as a general rule It is true that the author (1951) in treating consecutive series of patients by medical, mixed medical surgical, and by surgical methods (59 per cent of the cases operated on) found that the best results were in the last series On analysis however, it is seen that the cases he dealt with contained an exceptionally high proportion of elderly patients with chronic gastric ulceration (43 per cent of the patients were aged over sixty years and nearly 60 per cent of the ulcers were gastric) This type of case is particularly suitable for surgical treatment Such a high operation rate would be inadvisable in a series with a marked preponderance of young patients with duodenal ulceration

TABLE VII —*Peptic Ulcer and Gastritis Groups (Incidence of Bleeding)*

	Number of cases	Over 60 (per cent)	Operated on (per cent)	Overall mortality (per cent)	Average age of patient who died
Period No 1 1941–43 Operation avoided	193	33	5	10	6[illegible]
Period No [illegible] December 1943 to June 1944 Operation earlier Always gastrectomy	60	33	1[illegible]	[illegible]0	6[illegible]
Period No 3 June 1944 to December 194[illegible] Operation early Simplest to stop bleeding	31[illegible]	35	11	11	6[illegible]
Period No 4 January 1948 to September 1949 Finsterer	[illegible]1[illegible]	43	[illegible]	[illegible]	[illegible]
Period No 5 January to July 19[illegible]0 Selected surgery with bias toward conservative treatment	4	5 (34 over [illegible]0)	18	†13[illegible]	[illegible]

Improvements in medical management of the patient suffering from peptic ulcer hæmorrhage deal first with increased oral nutrition, replacement of blood and tissue fluids avoidance of hypoproteinæmia hypovitaminosis and hypokalæmia by the appropriate therapy and gentle limb and respiratory exercises As a result there is a diminished incidence of such complications as parotitis pneumonia thrombosis bed sores amblyopia and the general tissue damage consequent on anæmia Chemotherapeutic advances have made infective complications less lethal A most important result of maintaining the patient in a better state is that even late surgery can be undertaken with a much higher prospect of success (Bohn 1949) It is still a fact, however that if an emergency operation is necessary then the earlier the decision is made and the *intervention carried out the better the prognosis*

Thus the physician can contribute much to the success of surgical intervention by maintaining the patient in good condition and by requesting surgical aid without procrastination The more ready

co operation of the physicians has been won by lowered surgical mortalities This lowered surgical mortality is in part due to improvements in anaesthesia in chemotherapy in blood transfusion avoidance of the less effective operations e g gastrojejunostomy and the more widespread technical skill in performing the operation of gastrectomy

Indications for Surgical Intervention A high standard of skill and wide experience of dealing with gastro duodenal lesions is often required although some of the cases are technically not difficult Certain general criteria may be laid down, which are in fact very similar to those enunciated by Gordon Taylor seventeen years ago (1937) The statement he made then is still true— Every case must be considered on its own merits there can be no hard and fast rules

Briefly surgery is indicated if bleeding from a peptic ulcer is violent persistent or is repeated often enough to threaten life As however waiting to confirm that the hæmorrhage continues or is frequently repeated exposes the patient to grave risk, certain features of the case are picked out which indicate a particularly high risk of death from bleeding

Age The patient aged over forty five to fifty years is less able to withstand severe anæmia or hæmorrhagic shock and the healing power of the ulcer and contractability of the blood vessels are diminished Therefore surgery should be invoked much more readily in the older patient However young persons do sometimes die of ulcer bleeding and youth is not a reason for withholding operation if bleeding from a chronic ulcer persists or recurs more than twice While operation is often successful in the aged there eventually comes a time when the degree of senility and associated disease is such that an operation will almost certainly lead to death and it is better to let the patient rely on the slender possibility that bleeding may cease spontaneously

Catastrophic, Recurrent or Persistent Bleeding Particularly severe initial bleeding indicates that a large vessel is open and the risk of early death from exsanguination is present With each recurrence of bleeding the danger increases and in a patient over fifty with a chronic ulcer more than one recurrence of bleeding is usually regarded as a strong indication for surgery Persistent steady oozing requiring continuous transfusion more than thirty six hours after the onset of bleeding is an equally strong indication for surgery The persistence or repetition of bleeding in the hospital is usually more significant than a history of repeated vomiting of blood at home

Type of Ulcer The chronic ulcer is more prone to persist in bleeding though it is to be borne in mind that the acute ulcer or even an erosive gastritis may bleed persistently The dyspeptic history is usually the main evidence in favour of chronic ulceration, but there may be a previous history of ulcer perforation or bleeding, or even of a positive X ray examination to lend weight to the evidence In some clinics an emergency X ray examination by a barium meal or a gastroscopic examination is made during the first lull in bleeding after the patient's admission (Delannoy *et al* 1952 Palmer 1952 , Tanner 1949) These do not tend to provoke further bleeding and may make the cause of bleeding certain

In acute or gastritic ulceration operation may become necessary, though it is usual to operate only after at least two repetitions of bleeding in such cases even in the elderly, and still more persistence with medical treatment is justifiable in the young The late functional results of gastrectomy are better if a history of chronic ulcer dyspepsia precedes the operation

Other Features Another feature to consider is the state of the radial artery for bleeding is less likely to cease spontaneously, and vascular complications of anæmia, e g cerebral thrombosis are more likely if there is atheroma or arteriosclerosis Severe pain preceding the hæmorrhage or pain persisting after the hæmorrhage, is an unfavourable sign Noisy peristalsis on abdominal auscultation is suggestive of continued bleeding and the vomiting of clots suggests severe bleeding

To this list another class of case may be added This is the patient with a chronic ulcer who judged by his history, requires a gastrectomy (and sometimes is even on a hospital waiting list for interval operation) and who is admitted shortly after the onset of hæmorrhage In such cases operation is justified by its prophylactic effect against further bleeding as well as by its cure of the ulcerative condition

Severe bleeding associated with duodenal stenosis is a hazardous complication and is best treated by operation with careful pre operative and post operative correction of fluid and salt depletion Acute ulcer perforation associated with severe bleeding is an absolute contra indication to conservative treatment and the ulcer should be resected rather than simply sutured

Operative Procedures In all operations for ulcer hæmorrhage a good drip blood transfusion is set up prior to operation the stomach is aspirated and a small stomach tube left in It is impossible to aspirate all the clot from the stomach and so the anæsthetist must be prepared for the possibility that clots may be vomited In some

centres pure local anæsthesia is favoured, partly because of the *danger of clot vomiting under general anæsthesia*

At laparotomy confirmation of the presence of the ulcer is first required, and particular care should be taken to ensure that a high posterior ulcer is not overlooked Inspection of the serosa for a blush or scar is made A small clump of enlarged glands may indicate the ulcer site Even gastrotomy or duodenotomy may be required to demonstrate the lesion

In the majority of chronic ulcers a partial gastrectomy is the most straightforward and reliable method of dealing with the *situation with reconstruction by gastro duodenal or gastro jejunal* anastomosis In the case of high gastric ulcers a tongue shaped upward extension of the resected tissue is made to include the ulcer (Pauchet) If a completely penetrating ulcer into the pancreas or other viscus is present the bleeding point may remain in that viscus when the stomach or duodenum is separated from it In such cases if a clot is seen in the ulcer base care must be taken not to disturb it—for once it is removed or aspirated it may require a good deal of effort to re arrest the hæmorrhage If the splenic artery is eroded as occurs with some posterior gastric ulcers then ligation of the artery will be required on *both* sides of its erosion If the ulcer is duodenal it may be necessary to pass strong sutures into the pancreas in order to bring together the ulcer edges in the pancreas and so occlude the bleeding point At other times it may be helpful to close the duodenal wall in one layer and then, by sutures between the anterior surface of the duodenum and the fibrotic crater edge in the pancreas the closed end is pushed into the crater to press on and arrest the bleeding from it

In certain cases less radical methods than gastrectomy may be recommended to arrest the bleeding For bleeding stomal ulceration it is sometimes wise to inspect the crater by anterior gastrotomy and simply underrun the bleeding point, keeping the major intervention for a second occasion The author has at times in aged poor risk cases with duodenal ulceration made an anterior duodenal incision arrested the bleeding by sewing the ulcer edges firmly together with silk repaired the duodenum—narrowing it and then made a gastro jejunostomy Though at times life saving bleeding may recur (twice in 10 cases in the writer s hands once fatally) Some advocate simple excision of the ulcer for small acute ulcers because the ulcer is mobile and the functional prognosis after gastrectomy not so satisfactory as is the case in chronic ulceration There is a risk of leaving a second ulcer in such limited resections and the author has given up this procedure except for rare occasions

It is indeed sometimes as difficult a procedure to carry out as a gastrectomy Local excision is also sometimes used for giant penetrating gastric ulcers in poor risk cases It must be remembered in such cases that the ulcer is always larger than its area of complete penetration and to arrest the bleeding satisfactorily the whole ulcer edge must be excised and firmly resutured In some cases resuture leads to such gastric narrowing that a gastro jejunostomy is needed at the end of the operation The indication for this operation again will be very rare

If the site of severe bleeding cannot be determined then it is generally wise to perform a partial gastrectomy In most cases all or part (e g in generalized erosive gastritis) of the lesion will be removed and even if it is not the remaining part of the stomach may have its blood supply diminished enough to cause the bleeding to cease Lewison (1949), who performed 56 partial gastrectomies with only 4 deaths found that only in 40 per cent of the cases was a source of the bleeding actually seen to have been removed None the less the surgical procedure caused the bleeding to cease Simple ligation of the main gastric vessels has been advocated in the past for these cases but it is an unreliable method

THE POST-GASTRECTOMY SYNDROME

HAROLD C EDWARDS

REMOVAL of the stomach or the greater part of it, deprives man of a very important though not indispensable, adjunct to digestion The effect of removal varies in different individuals In many it is negligible in a few, profound This variation is hard to explain for it will be apparent among patients who have been operated upon by the same surgeon in the same way Some small degree of difference in the effects has been discerned after different types of operation by some observers (O Neill 1950 Mimpriss and Birt 1948) but not by others (Goligher and Riley, 1952) and there is some relation between the severity of the disturbance and the amount of stomach removed (Pulvertaft, 1952, Goligher and Riley, 1952) But individual variations in the effects of removal cannot be satisfactorily accounted for thus The most variable factor is undoubtedly that of the ego or personality of the patient himself and it is in this obscure field that the chief reason for this wide difference in effects amongst individuals lies That the incidence of severe disturbances is less for one surgeon s patients than

for those of another is less a matter of technique than of selection of patients

The risk of developing severe symptoms after partial gastrectomy appears to be greatest for the nervous subject with a minimal degree of ulceration particularly if he had experienced *before* operation some of the post prandial symptoms—such as breathlessness palpitations, fullness fatigue—which are characteristic of the post gastrectomy syndrome Most of the many excellent investigations into the post operative histories of large groups of patients commence in point of time with the operation and lose much by not taking into account pre operation clinical and pathological detail An enquiry including this information would add greatly to our knowledge of pre disposition to post gastrectomy symptoms and help in the wise selection of patients for operation

The incidence of significant symptoms is impossible to assess Most patients after gastrectomy will, at least for a few months after operation admit if closely pressed to certain mild digestive discomforts Such symptoms of discomfort are gladly suffered in exchange for the great benefits conferred by the operation In a small minority only are the effects of so disturbing a nature that the patient regrets having submitted to surgery

The great prominence which lately has been given to the post gastrectomy syndrome is perhaps endangering the repute of the operation of partial gastrectomy and it needs therefore to be emphasized that partial gastrectomy for chronic gastric and chronic duodenal ulcer remains one of the most satisfactory operations in surgery provided the selection of patients is wisely made

The effects of partial gastrectomy may be divided into two groups which however are to some extent mutually interdependent They are (*a*) general nutritional defects and (*b*) subjective sensations (dumping)

General Nutritional Defects

Except when the patient has been starved before operation as a result of duodenal obstruction it is rare for him to put on weight after partial gastrectomy for ulcer irrespective of the type of operation performed The best he can do is to regain his pre operation weight and a number of patients fail even in this After total gastrectomy even for a simple condition (e g polyposis) patients may become and remain emaciated To Brain (1951) they are reminiscent of Belsen Muir (1949) gives the following data for eighty six patients following subtotal gastrectomy —

Exceeded pre operation weight	7
Attained pre operation weight or within a few pounds of it	44
½–1 stone below pre operation weight	16
1 –1½ ,, ,, ,, ,,	8
1½–2 ,, ,, ,,	7
2 –2½ ,, ,, ,, ,,	4

Pulvertaft (1952) finds weight loss more marked in women than men and that there is a general relationship between it and the degree of post operative symptoms This weight loss unless severe, is not necessarily associated with discomfort nor does it often disconcert the patient It may, however, reduce to a lower level than before operation what may be called the patient's vital potential There may be a permanent reduction in his powers of concentration and endurance (agastric asthenia of Buslov 1949), and of zest for normal pleasurable pursuits This is usually readily accepted by the older subject, and regarded as a small price to pay for restoration to a better level of health It may however be a serious handicap to the young and heavy manual worker It is on record that North American trappers and lumber men amongst whom duodenal ulceration appears to be common are rarely if ever able to endure again the physical hardships and laborious toil of their calling after partial gastrectomy

There are very many reasons for this nutritional defect some evident others obscure

Amongst the former are subjective symptoms (the dumping syndrome itself) reduced capacity for intake of food diminished appetite with distaste for certain foods especially fats and failure of fat absorption Among the latter are vitamin deficiencies, particularly of the B complex (Brain 1951 Welbourn and others 1951) pancreatitis and potassium deficiency (Smith, 1951)

Iron deficiency anæmia (microcytic anæmia) is not uncommon during the early post operative period particularly in women before the menopause, largely as a result of blood loss and depletion of iron stores but megaloblastic anæmia is extremely rare though macrocytosis unexplained but harmless is often to be found according to Brain (1951)

Finally evidence is now accumulating that these nutritional effects predispose to pulmonary tuberculosis

Subjective Sensations (Dumping Syndrome)

The subjective sensations which have from long custom been classified under the heading of the 'dumping syndrome refer to

symptoms directly due to the repercussions of the newly established anatomy and exclude those arising from such complications as recurrent ulcer stomal ulcer or jejunal loop obstruction

There is a certain incoherence about them for they vary so greatly in their numbers their severity their insistence their relation one to another the paths through which they may be mediated and their tendency to merge with the psychological

In the milder degrees the patient s complaint may be solely a feeling of epigastric fullness rarely amounting to pain within 20 to 30 minutes of starting to eat sometimes the sole or major complaint is regurgitation of bitter fluid into the mouth Both these or either one of them may be accompanied by a feeling of languour sometimes amounting to a feeling of complete exhaustion so that the patient is obliged to lie flat until he feels better He may feel dizzy and rarely actually faint There may be nausea and occasionally vomiting and diarrhoea Other bizarre sensations may be prominent or even predominant—such as breathlessness palpitation flushing sweating photophobia and a feeling of tightness of the scalp Occasionally the latter group is unaccompanied by any uneasy sensations in the abdomen itself

The more local or epigastric symptoms usually develop soon or immediately after operation and may pass off within a few weeks or months or become permanent The other or vasomotor symptoms may not develop for weeks or even months after operation and tend to persist In some they regularly follow all meals in others only certain meals during the day and may be particularly noticeable after sweet drinks In others they may occur as isolated episodes the patient being free of any untoward feelings for weeks at a time

A second type of malaise is one which may occur at a longer interval after the meal when digestion is reaching a more advanced stage These symptoms are very similar to the more immediate vasomotor symptoms and closely resemble symptoms typical of hypoglycæmia to which it is thought they are probably due (*q v*)

Physical signs accompanying the dumping syndrome are few There may be a pallor and sweating The blood pressure may be raised a little together with an increase in rate of the pulse and respiration and a small rise in temperature

Explanations for these symptoms have been eagerly sought and much difference of opinion as to the nature of their origin is in evidence Capper (1951) for example believes that the major factor may be due to drag on the gastric remnant following the loss of its

upper supporting ligaments, and has been able to relieve a number of severe cases by reconstructing the supports at a second operation. Symptoms may, however, follow total gastrectomy, and Capper's explanation will not, as he agrees, supply the full answer, though it may sometimes be a major factor. Efferent loop reflux is not regarded as a frequent cause, for symptoms may occur without this being demonstrated. Hypoglycæmia has been discounted as a cause for the early symptoms, both because of the time factor and because of failure to discover any correlation between the timing of the symptoms and the level of the blood sugar (Irvine, 1948; Machella, 1949; Butler and Capper, 1951; Muir, 1949).

Most observers agree that the crux of the matter is the rapid passage of undigested food from the gastric remnant—or, after total gastrectomy, the œsophagus—into the jejunum, but differ in their interpretation of the mode of the response of the latter to this hurried entry. It is tempting to think that simple distension of the jejunum by this undigested pabulum, to the reception of which the intestine is totally unaccustomed, is the exciting cause, for the symptoms may be reproduced by passing a balloon into the jejunum and distending it with air in the human subject whether or not a partial gastrectomy has been performed. Machella (1949) has shown also that various hypertonic solutions (glucose, protein hydrolysate, soldium sulphate) introduced into the jejunum, can also reproduce the symptoms, and as is well known hypertonic chyme attracts water to itself by osmosis; its bulk is thus increased and causes jejunal distension. Glazebrook and Welbourn (1952), in trying to confirm these observations, found spasm a prominent feature of the clinical picture. Sufferers from the dumping syndrome were given a hypertonic solution of dextrose mixed with barium (50 per cent. dextrose solution mixed with 8 oz. of barium) and the reactions of the jejunum were observed under X rays. The solution provoked dumping symptoms, but there was no evidence of jejunal distension, but only of rapid emptying. In some cases actual spasm of the jejunum was noted. In some kymographic records were made after introducing hypertonic glucose solution, and an increase in tone and a great increase in the height of the contractions were recorded. Glazebrook and Welbourn (1952) investigated the effect of hexamethonium bromide (C6) in these patients in doses of ½—1 grm. before meals and found that it usually had the effect of increasing the appetite and the amount of food which could be taken with comfort. Further, it reduced or abolished dumping symptoms and, as shown radiologically, increased bowel activity and the rate of passage of contents.

Butler and Capper (1951) had a parallel experience with the effect of sympathetic interruption in that they were able to influence favourably the symptoms in the majority of sixty one cases by performing a splanchnic block They concluded from this experience that the sensation is mediated through the sympathetic

Vagotomy has no benign influence upon the early dumping syndrome On the contrary it may provoke it

The Late Post Prandial Syndrome

Butler (1951) noted that some 5 per cent of patients after partial gastrectomy develop symptoms due to hypoglycæmia some time after a meal Nearly half of them had similar symptoms beforehand Muir (1949) also finds it uncommon and thinks it has received undue emphasis in the literature

The commonest symptoms are tremor of the limbs giddiness and profuse sweating associated with exhaustion (Capper 1951) The cause is linked with the rapid absorption of the sugar in the undigested gastric pabulum from the jejunum Sufficient insulin cannot be mobilized to bring about its storage in the liver and hyperglycæmia results (Wells and Welbourn 1951) Excessive production of insulin may however ultimately be stimulated so that the blood sugar in time rapidly falls to hypoglycæmic levels Blood sugar curves of this type are found in about one third of the patients after partial gastrectomy but in only about 15 per cent of these are symptoms produced (Wells and Welbourn 1951)

The symptoms may readily be relieved by swallowing a lump of sugar Ephedrine is also effective The syndrome frequently follows vagotomy (Pollock 1952)

The Relief of the Post-gastrectomy Symptoms

There is a general tendency for spontaneous improvement in all cases however severe the symptoms Eighteen months after operation Goligher and Riley (1952) in reassessment of 141 of 168 patients suffering in varying degree and which represented 75 per cent of all patients investigated found that the incidence of symptoms had fallen from 75 to 47 5 per cent and of severe symptoms from 12 5 to 7 1 per cent It would thus seem important not to resort too early to operative measures unless some obvious mechanical cause can be demonstrated

It is probably ill advised to attempt any form of therapy other than reassurance for the mild case In any event such patients do

not return with their complaints, which are usually only revealed after a purposive and objective inquiry

In the severe case, every attempt should be made to unearth the cause The patient will on occasion discover for himself what article of diet—such as sweet tea taken without solid food—is most likely to precipitate an attack, and avoid it Belladonna or ephedrine is sometimes effective if taken before meals, and hexamethonium may help those cases in which steatorrhœa is a prominent feature Machella (1949) recommends omitting fluids from meals and partaking of them between meals As an aid to fat digestion, and in the hope of increasing body weight it is suggested that the total fat intake be increased but spread throughout multiple small meals

In those cases which are incapacitating and fail to show improvement the effect of splanchnic block may be tried Occasionally (Capper 1951) lasting relief may thus be obtained Operations which have given relief to some cases are jejuno jejunostomy below the anastomosis conversion of the two jejunal limbs into one cavity continuous with the stomach (both these operations are only relevant when the afferent limb is long i e after the anterior polya), reconstruction of gastric ligaments (Capper) conversion of a Billroth II type of operation into a Billroth I

CARCINOMA OF THE STOMACH

The five year survival rate for patients with carcinoma of the stomach has risen according to the Mayo Clinic figures from 5 to 14 per cent during the past thirty years (Table Fig 33) This improvement though far less than could be desired is due to earlier diagnosis an increase in resectability rate and an all round advance in surgical management and anæsthesia There is little or no evidence as yet that it is due to any increase of the extent of tissue removed There is indeed no proven relation between the extent of the operation and the prospect of cure It has however been repeatedly shown that the outlook depends very largely upon whether operation is undertaken while the growth is still confined to the stomach or delayed until the lymphatic glands are infected The move to perform routinely a total gastrectomy for carcinoma of the lower half of the stomach is in fact unjustified by the evidence available Whatever theoretical advantages total gastrectomy may possess two important considerations weigh heavily against its practice —

(a) The primary operative mortality is significantly greater than that of subtotal gastrectomy and its routine performance would

probably lose more lives than it would save from recurrence in the gastric remnant

(b) The level of wellbeing is usually far lower after total than after subtotal gastrectomy

For these reasons the choice of operation for cancer confined to the distal half of the stomach is subtotal gastrectomy, with excision of the lymphatic drainage and the great omentum Total gastrectomy should be reserved for diffuse cancer, and cancer involving the upper half of the stomach

Though it goes without saying that early diagnosis which increases the possibilities of resection before lymphatic involvement has taken place, is the key to greater success, it by no means

	1907-16	1940-49
Total patients examined	100%	100%
Subjected to laparotomy	60%	80%
Lesion found resectable	22%	44%
Survive resection	19%	40%
Survive 3 years	7%	18%
Survive 5 years	5%	14% ±

FIG 33 Fate of patients with gastric cancer formerly and to day
(By courtesy Staff of the Mayo Clinic)

follows that any direct relation can be worked out between length of history and five year cure rate for the important arbiter of survival is the nature of the growth itself—as in carcinoma affecting other regions of the body A short history especially in the younger patient usually connotes a virulent type of growth for which surgery is unavailing A long history sometimes indicates a growth of low vitality It may also be that when a long history precedes operation, the patient has developed some degree of resistance to the cancer

In the author s experience the relation between length of history and resectability rate is as follows —

In 31 cases with a recorded history not exceeding 3 months only 8 were operable—in the sense that removal gave prospect of cure Of 31 with a recorded history of between 3 and 10 years 10 were operable Pack and McNeer (1948) record a similar experience

The best palliative operation is partial gastrectomy even if removal of the whole of the obvious extramucosal spread of the

growth is impossible There must be, of course, in some cases a narrow margin between what can be considered palliative and what can be considered radical The cynic may, in fact, and perhaps with some justification, regard all operations as palliative It is a commentary indeed on the unknown factors concerned in cancer growth and cancer resistance that many obvious palliative operations secure as long a survival rate as do radical resections

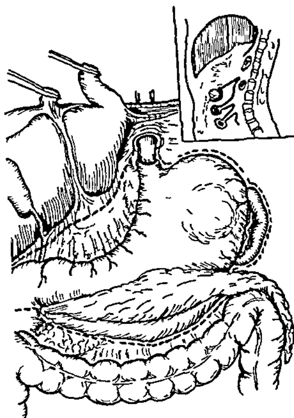


Fig 34 Anatomical approach to total gastrectomy
(Figs 34 and 35 by courtesy Dr J A Meyer and the Editor Surgical Clinics of North America)

There should even in the palliative operation be no hesitation in removing the mid portion of the transverse colon if the middle colic artery is involved in the growth Direct end to end anastomosis by single layer interrupted sutures of the residual colon is a safe procedure provided the patient s operation is preceded by a course of phthalylsulphathiazole, and streptomycin is given from the night before operation and continued until all danger of leakage is passed

Precision tests in diagnosis are still lacking though the greatest

hope seems to lie here in the adaptation to the stomach of Papanicolaou's (1950) cytological method Clinical assessment remains the most important diagnostic measure and where clinical evidence supports a diagnosis of carcinoma of the stomach despite doubtful or negative radiological and gastroscopic findings, exploration *should be undertaken*

The age old controversy about the incidence of malignant changes in gastric ulcer has burnt itself out Long experience has shown that peptic ulcers on the lesser curve of the stomach in women almost never and in men hardly ever, become malignant but chronic peptic ulcers in the pyloric antrum should always be suspect either of actual or of potential malignancy, and for them operation should invariably be advocated

Total gastrectomy for cancer of the body of the stomach should

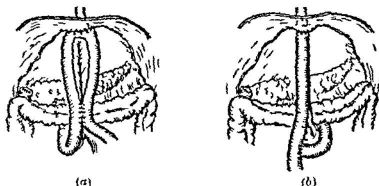


FIG 35 (a) End to side œsophago jejunal anastomosis (b) Roux en Y œsophago jejunal anastomosis

usually be performed through the abdomen There is rarely any justification for entering the thoracic cavity and abdomino thoracic exposure should be reserved for cancer at or near the cardia whether gastric or œsophageal Increase in the exposure afforded by the usual midline or paramedian incision may be obtained by excising the ensiform cartilage and by subcutaneous division of the lower left costal cartilages The extent of the radical operation is illustrated in Fig 34

Restoration of continuity after total gastrectomy is best obtained by œsophago jejunostomy, either end to side or end to end (Roux) (Fig 35) (see also p 83) In patients with mobile viscera œsophago duodenostomy may be a tempting alternative being quicker of performance

For cancer of the proximal portion many surgeons prefer to leave the pyloric antrum This method incre operatio

culty, however, and unless accomplished by some form of pyloroplasty, retention is liable to develop subsequently in the resulting pouch

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CHAPTER IX

THE GALL-BLADDER AND BILE DUCTS

HAROLD C EDWARDS

POST-CHOLECYSTECTOMY SYMPTOMS

A CONSIDERABLE proportion of patients are unrelieved of the symptoms for which cholecystectomy is undertaken, or subsequently develop a fresh series of symptoms referable to the biliary tract Pribram (1950) estimates the incidence to be 20 per cent, and Love (1952) 15 per cent, of the total The causes appear to fall into two groups

(a) Residual disease or development of structural changes in the bile passages

(b) Aberration of the control mechanisms of bile expulsion into the duodenum (dyskinesia)

Residual Disease and Structural Change

The danger of leaving stones in the common bile duct after cholecystectomy for calculous cholecystitis has long been recognized This risk can be significantly diminished by routine cholangiography performed at operation before the gall bladder is removed

Love (1952) has used cholangiography at operation in 322 patients, with only 9 technical failures and a positive result in 56 In 27 stones were revealed in 14 spasm of the sphincter of Oddi, in 11 chronic pancreatitis causing compression of the duct, in 2 carcinoma of the pancreas in 1 papilloma at the ampulla and in 1 a constriction by the hepatic artery

Though many of these conditions would be detectable by inspection and palpation there is no doubt that cholangiography in expert hands will make a gratifying contribution to precision in diagnosis Love s method is to inject 5–10 ml of a contrast medium such as neo hydriol or diodone into the common bile duct by means of a cannula entered through a small incision in the cystic duct Five seconds is spent over the injection and a radiogram taken immediately afterwards (Figs 36–39)

The stump of the cystic duct may be a potential source of trouble (Garlock and Hurwitt 1951) Calculi may be left within it or

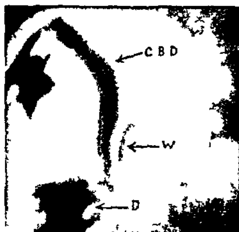


Fig 36 Normal cholangiogram showing regurgitation of fluid along duct of Wirsung (W) and free flow of fluid into duodenum (D)



Fig 37 Spasm of sphincter of Oddi Dilated common duct (C B D) No fluid enters duodenum Treated by division by sphincterotome

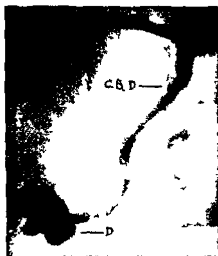


Fig 38 Compression of lower end of the common bile duct due to chronic fibrosing pancreatitis

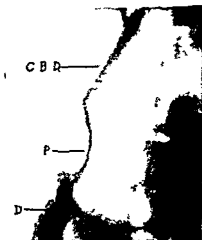


Fig 39 Filling defect in the common bile duct due to papilloma (P) which was excised transduodenally Small amount of fluid in duodenum (D)

(By courtesy of Mr P J M N ll Love and the Ed tor "The B t sh Jo rnal of Surgery")

possibly, develop there subsequent to operation It may distend to form a diverticulum which harbours infection It has been suggested also that failure to clean the duct meticulously before ligature at cholecystectomy may result in symptoms due to inclusion within the ligature of nerve filaments Opinion er as to wheth

at operation the cystic duct should be ligatured flush with the common bile duct Most surgeons would agree that it is safer to leave a short length—perhaps ⅛ in

Dyskinesia

Of recent years increasing interest has centred around the problem of symptoms referable to the biliary tract following cholecystectomy, and not occasioned by any discernible organic lesion The incidence of such symptoms appears to vary considerably in different clinics and there is reason to believe that they most frequently follow cholecystectomy performed for minimal lesions in the gall bladder This experience underlines the need for observing strict criteria for the operation of cholecystectomy and apart from new growth, limiting the operation in general to calculous cholecystitis and in general abjuring it for non calculous cholecystitis

Removal of the gall bladder may undoubtedly upset the mechanism of biliary flow into the duodenum sometimes to the extent of causing symptoms more troublesome than those for which cholecystectomy was performed In certain cases pre operative symptoms may have in any case been due to dyskinesia and removal of a gall bladder which was itself not responsible may have the effect of increasing the severity of symptoms arising from this cause

Pribram (1950) believes that the effects of deprivation of each of the main functions of the gall bladder as a result of cholecystec tomy are as follows —

A Functions related to cholokinesis (expulsion of bile)—

1 Regulation of bile pressure in the bile ducts the gall bladder working as an overflow reservoir and tension bulb Clinical syndromes of missing function pressure syn dromes cramps in the right upper abdominal quadrant suggestive of real colic nausea and the like

2 Neuroregulation of gall bladder contraction in relation to opening reflex of the sphincter—
Clinical syndromes of missing function dyskinesia of the sphincter—

(a) Spasm leading to increased pressure syndromes and biliary stasis favouring development or flare up of cholangitis or pancreatitis

(b) Paralysis of the sphincter leading to diarrhœa and enteritis

B Functions related to biochemical properties of concentrated gall bladder bile—

Aid in digestion of food particularly fat, bile salts and other secretions assisting the actions of the lipases

Clinical syndromes of missing function lowered tolerance to food especially fat anorexia and flatulence

The clinical pattern is somewhat confused, and it may be difficult to distinguish between hypo and hypertonia, although Newman (1933) made an attempt to elucidate their distinctive features In the main hypertension gives rise to period attacks of pain of a few minutes duration and is associated with loss of weight and occasionally transient jaundice secondary cholangio hepatitis or pancreatitis may be observed The hydrochloric acid concentration in the gastric juice may be high or normal Hypo tension is likely to cause a flatulent dyspepsia nausea and appetite loss and in severe cases diarrhœa because of unlimited and con tinuous passage of bile through a paralysed sphincter of Oddi into the duodenum Hypochlorhydria is the rule

Attempts have been made to record the degree of tension within the common bile duct by manometry at operation Mallet Guy (1949) performs this examination as a routine and bases his future medical and surgical care upon the interpretation of the results obtained combined with those from routine radiology of the bile passages

Hypertonia appears to be more common than hypotonia The treatment of both in the first instance is medical That for hyper tonia is based upon the principle of prevention of sphincter spasm—the avoidance of stimulating ingredients in diet and the adminis tration of antispasmodics For hypotonia, improvement may follow administration of HCl and pepsin after each meal (Pribram)

Surgical treatment must necessarily only be entertained if the symptoms are severe special attention being paid to any psycho logical background for lack of knowledge prevents complete reliance on any operative procedure the outcome of which is to be regarded more in the light of hope than certainty

Neurogenic Control of the Sphincter of Oddi

Though we are lacking precise knowledge of the nerve supply to the sphincter of Oddi there is reason to believe that the para sympathetic nervous system through the right vagus maintains tonic control and that right vagotomy will relax spasm of the muscle Crile and Miller (1951) have put this theory to the test in 9 patients performing a bilateral vagotomy in 5 and a right vago tomy in 4 It was found that bilateral vagoto ore effectiv

than right vagotomy Coleman and Bennett (1952) record relief of symptoms in bilateral vagotomy in 5 patients

Mallet Guy (1951) recommends right splanchnicotomy in the treatment of hypotonia demonstrated manometrically and radiologically, and has performed this operation on 135 patients with 82 per cent of "perfect" results

Most surgeons will not however, be attracted to such procedures as vagotomy or splanchnicotomy for the relaxation of a spastic sphincter or the rehabilitation of a relaxed sphincter until far more certain knowledge of the regulation of the musculature at the ampulla is known, and would prefer to rely upon a more direct procedure Two possibilities present themselves for the relief of hypertension—choledocho duodenostomy and sphincterotomy If the common bile duct is grossly dilated, the former operation is the one of choice for it is simple to perform, and will ensure bile drainage

The results of division of the sphincter are likely to be less certain particularly if performed by means of a sphincterotome introduced through the common bile duct as recommended by Doubilet and Mulholland (1948) On the other hand, transduodenal exposure of the ampulla and division or partial excision, of the sphincter is often difficult to accomplish, and not without risk, though Lester and Colp (1952) have recorded a good proportion of satisfactory results in 21 cases followed for between three and fourteen years Simple dilatation of the sphincter through the common bile duct is not more likely to give permanent relief than dilatation of physiological or organic strictures occurring elsewhere in the body

REPAIR OF THE BILE DUCTS AFTER INJURY

Damage is usually due to errors of technique, abetted by operating under conditions where proper facilities are lacking Fibrous obstruction to the common bile duct may however develop many years after cholecystectomy performed without any observable fault

Injury to the common bile duct appears to be most often inflicted if cholecystectomy is performed when the gall bladder is acutely inflamed anatomical details being obscured by œdema, and this constitutes an argument against routine operative treatment for acute cholecystitis The most vulnerable areas are at the junction of the cystic duct with the common bile duct and at the level at which the cystic artery passes under the latter to reach the

gall bladder. Should the artery be divided accidentally before ligature, or should the ligature slip from around it, temporary hæmostasis may be obtained by compression of the hepatic artery as it runs in the gastro-hepatic omentum (Lahey, 1950). A successful outcome of operation for common bile duct damage can only be hoped for at the first attempt. Patients whose jaundiced existence is punctuated by repeated visits to the operating theatre rarely if ever regain a satisfactory biliary mechanism. The most favourable circumstances should therefore attend the operation.

One absolute essential to success is full and free exposure, and when the liver is so large as to be an embarrassment to exposure of the damaged bile duct through an abdominal incision consideration should be given to exploration through a right thoraco-abdominal wound. This enables the liver to be rotated backwards and upwards into the chest so that the hilum is fully exposed to view.

For reconstruction a mucoso-mucosal suture line is the desideratum. The ideal is to secure direct union between the two ends of the common bile duct. Failing this, the upper end may be sutured end to end to a long limb of the jejunum prepared after the Roux principle. The result from the latter operation may however be marred by recurrent infection of the biliary passages from the small bowel. Other operations such as first of all establishing an external fistula which is subsequently implanted into the duodenum or jejunum are unlikely to give permanent relief. Longmire's (1948) operation, in which the cut surface of the liver is anastomosed to the jejunum after resection of the greater portion of the left lobe of the liver, can only be effective if the damage is below the union of the hepatic ducts; otherwise the right lobe of the liver will not drain via the left lobe into the jejunum. As Lahey (1949) pointed out, if the obstruction is not above this, direct anastomosis either to the lower end of the duct or to the jejunum should be technically possible. The only indications for operations of this type are when previous unsuccessful operations have "used up" any upper duct remnants. In general, permanent indwelling tubes should be avoided.

If a simple stricture is present, that is to say the common bile duct has not been completely divided, direct anastomosis over a T-tube which enables drainage to be established should be feasible. If the common bile duct has been completely divided the upper end will be bulbous (drumstick ended) and unless the duct has been obliterated as a result of infection it should be recognized without great difficulty. If the damage lies at, or above ... of th

hepatic ducts, the two lumina may be converted into one by Cattell's manœuvre (Fig 40) preparatory to anastomosis either with the lower end of the duct or with the jejunum It may be extremely

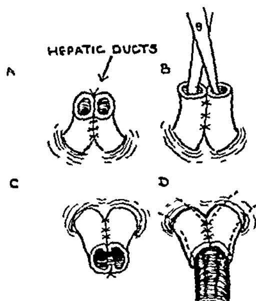


Fig 40 Cattell's manœuvre Fusion of lumina of hepatic ducts to make a single tube

difficult to find the lower end of the divided duct, for its calibre will be shrunken In order to obtain sufficient length of duct for suture the duodenum is rolled over to the left and the duct freed

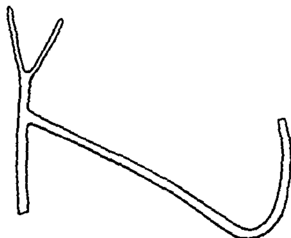


Fig 41 Lahey tube forked for accommodation within the hepatic ducts

Figs 40 and 41 by courtesy Dr F H Lahey and the Editor Surgery Gynecology and Obstetrics

from the pancreas by splitting the latter if need be to the level of its union with the pancreatic duct Direct union should be made over a T tube so that prolonged drainage may be instituted When the lesion is situated near the hepatic duct, the upper short limb of the tube may be split, one moiety being placed in either hepatic

duct Lahey has had prepared for use in such cases a T tube with the upper limb forked for accommodation within the hepatic ducts (Fig 41)

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CHAPTER X

THE PANCREAS

HAROLD C EDWARDS

CANCER OF THE PANCREAS

It is well recognized that cancer of the pancreas occurs in two chief forms —

Cancer at the Ampulla This may be a papillomatous growth projecting into the duodenum or a flat ulcerating growth which may cause obstructive jaundice when it is still so small as to be barely detectable at operation

Cancer of the Main Gland The head comprises about two thirds of the pancreas and it is thus but natural that two thirds of the recorded cases of pancreatic cancer arise within it Though jaundice

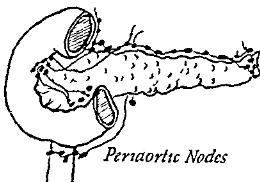


FIG 42 Lymphatic drainage of the pancreas

From Surgery of Pancreatic Tumours by courtesy of Dr A Brunschwig and Messrs Henry Kimpton Ltd

is a common—almost constant—development it may not appear until the growth is extensive and the lymphatic glands have become involved The growth is an adenocarcinoma and is commonly of a high grade of malignancy Spread may occur at an early date to the three main peripancreatic lymphatic gland groups—supero lateral lying beneath the pylorus the infero lateral lying over the uncinate process of the pancreas , and the splenic chain lying in front of the body of the pancreas in relation to the splenic vessels (Fig 42) From these spread may occur to the hepatic lymphatic glands Secondaries in the liver may appear later Spread may also occur to the periaortic nodes and nodules may appear

duct Lahey has had prepared for use in such cases a T tube with the upper limb forked for accommodation within the hepatic ducts (Fig 41)

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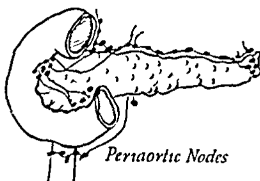


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ordinary Polya operation in front of the colon Implantation of the residual pancreas *into the jejunum* may be a procedure of some difficulty as a meticulous anastomosis is impossible and there is often disparity between the size of the cut surface and the diameter of the jejunum There are two possible alternatives (*a*) Implantation into the open end of the jejunum at the point of section

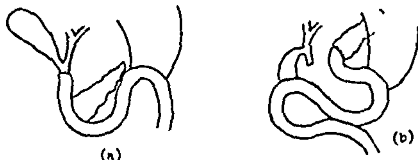


Fig 44 Alternative methods of reconstruction after partial pancreatectomy (see text)

(*Fig 44b*) (*b*) *Implantation into the stomach* (*Wells and others*, 1952)

When jaundice is severe, and the patient s condition appears unlikely to withstand a one stage procedure, preliminary drainage of the gall bladder into a loop of the jejunum is the first step

Results

The best prospect for operative success is for growths situated at the ampulla of Vater for attention is brought to the presence of the latter by the onset of jaundice while the growth is still localized The prospect of cure of cancer of the head diminishes proportionately to the distance of the origin of the growth from the ampulla because the clinical symptoms which it produces are so slight and so obscure that its presence before jaundice develops can rarely be suspected Experience has now shown that by the time jaundice due to cancer of the head of the pancreas has developed, the growth is too advanced to offer much if any prospect of cure Operation results to date certainly give room for doubt as to whether pancreatico duodenectomy for pancreatic cancer situated elsewhere than at the ampulla is capable of prolonging life and comfort to a degree appreciably greater than will palliation of the jaundice by a short circuit operation

Cattell and Pyrtek (1949) were able to perform a pancreatico duodenectomy on 56 of 165 patients explored Of 20 in whom the growth was at the ampulla, of whom 1 died from operation, only 3

on the peritoneum with the development of ascites Blood borne spread to the lungs is a late finding and skeletal metastases are rare

Radical Operation

Small mobile ampullary growths in which there is little evidence of extension into the head of the pancreas—this applies particularly to the papillary type—may be satisfactorily treated by transduodenal section with re implantation of the common bile and pancreatic ducts into the duodenum, a method which has been employed spasmodically since the first recorded attempt by Halsted in 1898

The radical operation for the larger ampullary carcinoma is however similar to that for the head of the pancreas The affected portion of the pancreas is removed together with the duodenum and the lymphatic glands draining the pancreatic head The amount of

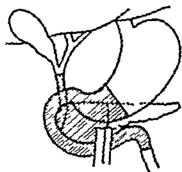


Fig 43 Partial pancreatectomy Extent of incision

pancreas to be removed in cancer of the head will depend upon the extent of the growth but as Brunschwig (1944) has insisted, the growth must be given a generous margin for it is impossible to define its exact limit by palpation The whole duodenum to a point beyond the flexure together with the pyloric end of the stomach is removed (Fig 43) If the superior mesenteric vessels are involved the case is inoperable

After removal the surgeon has three main problems—restoration of continuity of the alimentary tract, of the biliary tract and the disposal of the cut surface of the pancreas It is customary amongst most surgeons to place all three into the jejunum in the order of biliary tract pancreas and stomach This may be done either into a loop of jejunum anastomosing the two limbs at a convenient point, or into a long limb of jejunum (Fig 44a)

Either the gall bladder or the common bile duct may be implanted into the jejunum This can be an end to end procedure if the Roux operation is decided upon The stomach is anastomosed as if for an

ordinary Polya operation in front of the colon Implantation of the residual pancreas into the jejunum may be a procedure of some difficulty as a meticulous anastomosis is impossible and there is often disparity between the size of the cut surface and the diameter of the jejunum There are two possible alternatives (*a*) Implantation into the open end of the jejunum at the point of section

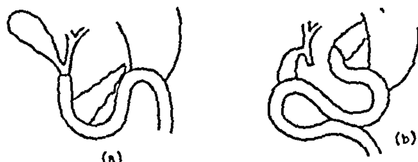


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were known to have lived for five years. Of 30 patients with cancer in the head of the pancreas, there were 5 post operative deaths and of the remaining 25, 18 had died within nineteen months. The longest survival at the time of the report was three years and seven months. Rodney Smith (1953) records 7 radical resections of 28 patients explored, 2 being the subject of ampullary and 5 of pancreatic growths. The former 2 survived eighteen months, but the longest survival of the second group was ten months. Miller and Clagett (1951) report 1 five year survival of 11 radical operations for cancer of the head and 3 of 7 radical operations for cancer of the ampulla.

There is little evidence that total pancreatectomy for carcinoma of the head as opposed to partial pancreatectomy, offers any better chance of cure. Patel (1951) reports that of 26 total pancreatectomies 11 died post operatively, 10 within fifteen months and the longest survivor of the 5 remaining alive is eleven months.

Diagnosis

Improvement in the results are only to be achieved if the diagnosis of cancer of the pancreas can be made before the onset of jaundice. The difficulty in so doing is well illustrated by the experience of Brown and others (1952) who record that in only 6 of 37 patients fully investigated was a preoperative diagnosis possible. All observers agree that the most frequent symptom is pain in the right hypochondrium often radiating through to the back and, according to Smith and Albright (1952), aggravated by the supine and relieved by the erect position. It is characteristic of the pain that it persists without remission. Other related symptoms are progressive weight loss and anorexia. Hypochromic anaemia is usually present and occasionally bouts of low fever associated with leucocytosis. Dyspepsia too ill defined to be pathognomonic may also be a feature. There may be evidence of pancreatic deficiency, e.g. mild and transitory glycosuria and excess of fat in the stools. With such symptoms the diagnosis can be little more than a surmise and can only be ascertained by exploratory laparotomy which should be advocated when a clinical history of this nature is related.

One of the quite unexplained complications of the condition is venous thrombosis affecting one of the peripheral veins in the leg or arm.

Even when the abdomen is open it is often difficult by inspection and palpation to determine the nature of a swelling of the head of the pancreas and pancreaticoduodenal resection has in fact been carried out in error on more than one occasion for chronic pan

creatitis Microscopy can make the distinction in some cases d Offay (1946) recommends a preliminary short circuit operation and lymph gland biopsy to be followed by radical excision if cancer is found Removal of a portion of the tumour mass for biopsy entails some risk of causing a pancreatic fistula Moreover as Probstein (1950) and others have shown, it is very unreliable because of the uncertainty of including a portion of any growth which may be present, in the biopsy specimen Probstein found that 11 of 18 patients in whom this type of biopsy showed results negative for growth subsequently were proved to have cancer Kirkland (1951) recommends needle biopsy using a hollow needle which removes a cylinder of pancreatic tissue 16 mm × 1 mm In his hands the method has given satisfactory results without causing the development of a fistula such as might be expected from excising a portion of the swelling for microscopy

DIAGNOSIS OF OBSTRUCTIVE JAUNDICE

What may prove to be an important contribution to the diagnosis of obstructive jaundice has been made by the trial of percutaneous transhepatic cholangiography in which a few millilitres of 35 per cent diodone are injected directly into an intrahepatic bile passage (Nurick Patey and Whiteside 1953)

The method is capable of giving excellent and often diagnostic X ray pictures when obstruction to the common bile duct is present, but in the absence of chronic obstruction, no filling of the biliary system with dye in sufficient concentration for radiography is likely to occur (Figs 45 a and b)

The examination is not without risk, however, one patient in the series recorded by Patey and his colleagues dying as the result of intraperitoneal leakage of bile and blood In these authors view this risk is lessened if routine treatment with Vitamin K is instituted before the investigation, and the test delayed until prothrombin readings are satisfactory Furthermore the amount of die injected should be limited to 20 mls and in the event of clinical evidence of leakage of bile into the peritoneum after the injection early laparotomy and drainage should be carried out

Patey and his colleagues describe their technique in the following words —

The procedure was performed on in patients in the X ray department after a preliminary injection of morphine The site for the injection was the anterior abdominal wall close to the right costal margin and about 1½ to 2 inches from the ensiform cartilage

This area was anæsthetized with 2 per cent novocain and a graduated needle 12 cm long and 1 mm in external diameter, fitted with a sight feed and stylet was introduced backwards slightly upwards and to the right until it was felt to enter the liver This was confirmed by noting that the needle moved with respiration The stylet was then removed and a 20 ml syringe containing saline connected by a rubber tube fitted with adaptors The needle was



Fig 45 (a) Film taken in erect posture showing dilated biliary tree and an irregular obstruction of the common hepatic duct
(By courtesy M [illegible] D H P[illegible] and the Editor British Journal of Surgery)

slowly advanced while an assistant maintained suction on the syringe When as frequently happened a portal radicle was entered the blood was washed out of the sight feed by injecting a few millilitres of saline Suction was also maintained during withdrawal of the needle If no bile was detected the needle was reinserted in a slightly different direction the stylet being occasionally inserted to make sure that the needle was not blocked When a bile duct had been located a few millilitres of 35 per cent diodone were injected and a check radiograph taken to confirm that the biliary tree was



Fig 45 (b) Oblique view erect posture Complete obstruction of the common bile duct confirmed at operation

filling Twenty ml of 35 per cent diodone was then injected slowly under screen control and the needle withdrawn A series of radiographs were then taken including some in the erect posture

HYPERINSULINISM AND ISLET CELL TUMOURS

The phenomenon of episodic hyperinsulinism and hypoglycaemia was first described by Harris in 1924 and in the same year W J Mayo removed a malignant tumour from the tail of the pancreas which proved on investigation to originate from the islet cells of Langerhans Five years later Graham of Toronto removed a spherical islet cell tumour from the body of the pancreas and thereby cured a patient subject to attacks similar to those described by Harris Whipple (1944) reviewed 144 cases of islet celled

tumours occurring in patients with hypoglycæmia and in 1952 recorded his personal experience with the surgical treatment of 39 patients

The characteristic features of recurrent hyperinsulinism and hypoglycæmia are threefold ('Whipple s triad')

Firstly attacks of hypoglycæmia secondly the finding of a blood sugar of 50 mg per cent or less at the time of the attack, or after a twenty four hour fasting period, and thirdly prompt relief from the ingestion of glucose

The attacks of hypoglycæmia are of varied intensity They are liable to come on during the fasting period before breakfast or after severe mental or physical effort when the sugar reserves are low They are grouped by Wilder (1943) under three headings (a) Those relating to disturbances of the vegetative system—nausea, sweating pallor flushing chilliness syncope (b) those relating to the nervous system—restlessness tonic or clonic muscle spasms opisthotonos convulsions and (c) psychic disturbances such as apprehensiveness confusion disorientation mania unconsciousness and coma Whipple s first six cases were referred by neurologists

Less frequently digestive disturbances and pain also occur In long standing cases mental deterioration may become severe and permanent with degenerative changes in the central nervous system Extreme obesity may also develop

These manifestations (Whipple s triad) are due to hyperinsulinism—they may occur of course when an overdose of insulin is given—and result from over production of insulin either by over active normal glands by hyperplastic islet cells or by tumours of islet cells The last is the most common cause and the spasmodic nature of the attacks is probably explained by the intermittent lack of control over secretion from the cells of the tumour

The tumour itself may be simple or malignant but microscopy is often incapable of making the distinction which is usually only made possible by the occurrence of malignant infiltration of structures around the pancreas or the presence of secondary deposits in the lymphatic glands or liver Less than 10 per cent behave in this way (Morley 1952) The tumours themselves are usually round bodies of some 2 cm in diameter (the size bears little relation to the severity of symptoms they may cause) and are of a more reddish hue than the normal pancreas surrounding them being covered by enlarged and dilated blood vessels They may be multiple (12 6 per cent Howard and others 1950) and may occur anywhere in the gland but are found most frequently in the body and tail where islet tissue is most abundant They ... r than

the normal pancreas and can be differentiated from it by palpation

Microscopically much variation is shown—from a typical adenomatous appearance to one showing scattered collections of islet cells in a degenerate fibrous stroma. The cells may be poorly differentiated and their appearance suggestive—but not pathognomonic—of malignancy. The early concept that the tumours were β celled adenomata is now discarded for it is almost impossible in most specimens to identify the cells with sufficient precision to justify the appellation. Holmes Sworn and Edwards (1946) doubt whether the tumours are adenomata and think it more probable that they are examples of hyperplasia. It is of interest to note that such islet cell tumours may be present in the pancreas without giving rise to symptoms of hyperinsulinism. On the other hand, exploration has sometimes failed to reveal the presence of localized adenomata even when the clinical picture is typical. In many cases however adenomata have been found at re operation or on detailed examination of the part of the pancreas removed at operation or at post mortem on operation fatalities. The most careful palpation of the pancreas is needed to reduce the numbers of missed tumours to a minimum and this applies especially to the head where most of the re operation tumours have been revealed. The duodenum should be mobilized so that a finger can be passed behind the pancreas and the head of the latter palpated between that finger and the thumb. Similar examination (made possible by incising the peritoneum at the lower edge of the pancreas) should be made of the head and tail. As the tumours are sometimes multiple the surgeon should not be satisfied with the finding of one but should examine the pancreas thoroughly to exclude the presence of others. The tumours should be removed completely with a narrow margin of pancreas around them. If no tumours are found in a case presenting the typical syndrome resection of 3/4 to 4/5 of the pancreas (from the tail end) is recommended.

Presumably in some of the cases in which no tumour is found and yet which benefit from operation the condition is due to overactivity of normal cells. In others adenomata may be found on careful dissection of the portion of pancreas removed at operation. Maxeiner and Bundy (1945) describe 9 such examples. In 9 cases explored a second time Whipple found that all had tumours which were missed at the first operation. Most of them were in the head of the pancreas. Persistence of blood sugar below 50 mg per cent after partial pancreatectomy is strong evidence that an adenoma has been overlooked. Sometimes the tumour is extrapancreatic—one has been described situated on the duodenal wall another

adjacent to the inferior border of the pancreas, a third growing from aberrant pancreatic tissue in the liver, and a fourth in the gastro splenic omentum

Islet cell carcinomas may behave similarly, although not all produce hyperinsulinism Some tumours diagnosed microscopically as carcinomas may have been simple because the patient remained free from recurrence of symptoms for years after their removal

Unfortunately hypoglycæmia may occur from other causes the pancreas being normal and there is no sure way of distinguishing between patients who have tumours and those who have not It has been described for example, in toxic hepatitis of various types in pituitary tumours in hypo and hyperthyroidism as a complication of Addison s disease and in various psychoses It may occur in otherwise healthy subjects—even athletes—as hypo glycæmia of effort and also in subjects with a low renal threshold for glucose In spite of a certain margin of error however, operation is advised if Whipple s triad is present, for the results in most cases are brilliantly successful in contrast to the results of medical treat ment Administration of sugar and other carbohydrates to control recurring insulin shock results in great obesity and if continued for a lengthy period converts the patient into a bad operation risk prolonged hypoglycæmia has a tendency to cause mental deteriora tion and anxiety neuroses and there is much uncertainty as to how soon a benign islet celled tumour may show malignant change

For the operative approach a transverse incision is recommended with a vertical limb in the mid line passing upwards if exposure is difficult Access to the pancreas is obtained either through the gastro hepatic omentum or the gastro colic omentum whichever seems the better in the individual case

Exposure of the pancreas should be complete so that it may be examined thoroughly Hæmorrhage will be troublesome, but every effort must be made to stop it completely before closing the abdomen A drainage tube is essential for some temporary leaking of pancreatic secretion may occur

CHRONIC RELAPSING PANCREATITIS

Chronic relapsing pancreatitis in which there is frequently an alcoholic history is a condition in which fibrosis spreads progressively throughout the whole gland with a tendency to the formation of cysts which may become very large Calcification may develop and the condition may be associated with stones in the pancreatic ducts

In the more severe cases, relapses are frequent malnutrition is progressive and respiratory tract infection or tuberculosis is a frequent terminal event The serum amylase is usually raised particularly during relapse but its level is subject to wide variations

The ætiology of chronic relapsing pancreatitis is not known but the consensus of opinion is that reflux along the pancreatic duct is a probable causal factor in many cases Where no discernible disorder is present in the biliary tract it is thought that reflux may be due to spasm of the sphincter of Oddi which Mallet Guy (1949) and Love (1952) have been able to demonstrate at times by cholangiography at operation (Fig 37)

The predominant symptom is pain, radiating to the back which may be constant and severe and quite unbearable during a relapse It is the presence of this symptom that has led to the attempts to obtain relief by surgery Because of varying appreciations of the ætiology many different surgical approaches have been made, which may be summarized thus —

(*a*) Partial or total pancreatectomy

(*b*) Operations upon the biliary tract designed to reduce tension—
  1 By pass operations e g Cholecysto enterostomy
  2 Section of the sphincter of Oddi
  3 Prolonged external drainage of the common bile duct

(*c*) Vagotomy to reduce pancreatic activity and spasm of the sphincter of Oddi

(*d*) Sympathectomy primarily for the relief of pain

It is clear however that the first essential in the operative treatment of pancreatitis is a detailed exploration of the bile ducts and gall bladder and the treatment on its merits of any pathological condition found In the absence of gross disease evidence of sphincter spasm will be given by the presence of dilatation without change in its texture of the common bile duct a condition which may be confirmed if radiological facilities exist by cholangiography The choice of operation then appears to be cholecysto enterostomy or choledocho enterostomy for either of which many surgeons prefer an end to end anastomosis with a Roux fashioned jejunal limb The advantage claimed for this complicated procedure over anastomosis to a jejunal loop is that it reduces the hazard of ascending biliary infection

Total pancreatectomy can rarely be considered, for apart from relief of pain which should be attempted by less radical measures the patient is no better off for the consequences of loss of the whole pancreas results in severe and protein maldigestion and in many cases, surgical diabetes Occasional good results are reported

after partial pancreatectomy but as the condition usually affects the whole pancreas its application is extremely limited

Purely for the relief of pain the best results are to be obtained from sympathectomy There is considerable difference of opinion however as to the extent of the operation and as to whether it should be bilateral or on the right side, or on the left Mallet Guy and Beaujeu (1952) perform splanchnicectomy only, and upon the left side They believe that this operation has a curative effect by reducing the tendency to œdema and claim a good result in thirty of thirty five operations

Cogswell (1951) recommends the thoraco lumbar operation including 8 cm of the greater splanchnic nerve Rack and Elkins (1950) who incidentally failed to obtain any improvement by vagotomy recommend bilateral sympathectomy from T10 to L1 and point out that the operation while relieving the pain will not affect the course of the disease de Takats and others (1950) recommend splanchnic nerve section, and excision of dorsal sympathetic chain from ninth to twelfth segments Ray and Console (1949) recommend bilateral resection of the greater splanchnic nerves and all other nerve fibres connecting the cœliac plexus with the lower thoracic and upper lumbar sympathetic chains

The essential is division of the greater splanchnic nerve which may be achieved below the diaphragm and should usually be bilateral This operation may also be effective in relieving pain due to pancreatic cancer

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CHAPTER XI

√THE SPLEEN

HAROLD C EDWARDS

DURING the past decade fresh concepts of the part played by the spleen in blood disorders have quickened interest in the possibilities of splenectomy and we are greatly indebted in this respect to American observers prominent among whom are Dameshek and Doan

Function

To day at least some of the functions of the spleen are known beyond reasonable doubt, and these include the following —

1 The production during fœtal life of all types of cellular elements of the blood and the power to return to this activity should the need arise during later life as it may in disorders leading to destruction of the bone marrow

2 The elimination of effete red blood cells from the circulation

3 Control of the activity of the bone marrow

In disorders of such functions the spleen may clearly be responsible for some of the blood dyscrasias or for aggravating them and the term ' hypersplenism is used to indicate an increase in the spleen s activity in respect of (2) and (3)

The reverse state hyposplenism is not descriptive of any clinical condition for extirpation of a normal spleen is not usually followed by any appreciable consequences to health It is indeed becoming increasingly the practice of the surgeon to remove the spleen during an operation in the splenic region merely because its presence may embarrass him It may be argued that this is carrying contempt for the normal spleen a little too far for there is a much increased tendency to thrombosis after splenectomy which may find expression in thrombosis of the splenic vein with spread to the portal or superior mesenteric vein Quan and Castleman (1949) record 6 such sequels to 70 splenectomies incidental to other operations

There is too a possibility that infections are less readily resisted by a patient whose spleen has been removed It is known that the resistance of splenectomized rats to infection by bartonella is

reduced and there is evidence that resistance to cancer may also be lessened in laboratory animals by splenectomy There is also evidence in man that splenectomy impairs resistance to malaria

Hypersplenism

Moyitz (1949) interprets *hypersplenism as a functional state* characterized by anæmia leukopenia thrombocytopenia or any combination of these three peripheral deficiencies associated with a normal or an increased amount of precursor cells in the bone marrow he considers that it can be primary or secondary In the former circumstance removal of the spleen should cure in the latter it should ameliorate The matter however, is not quite so simple as this for in addition to exerting to excess its capabilities of hæmolysis and suppression of the bone marrow, the spleen may revert at the same time to its prenatal function of producing new red cells to take the place of the dead ones—rather like he who robs the poor and gives to charity to expiate his crime

There is some doubt about whether hæmolysis, or interference or suppression of hæmopoiesis, is the only or the major, factor in hypersplenism More is certainly known of hæmolysis than of suppression and the role of the spleen in its causation can be better gauged

The life of the red cell in health is probably about 120 days If its life span is appreciably curtailed, anæmia will result unless the bone marrow can overwork itself to compensate If an anæmia results from this cause and is associated with a large spleen splenectomy will probably restore the life of the red cells to normal One might add that the larger the spleen the more assured can one be of the favourable outcome of its removal

The presence of severe hæmolytic crises is usually obvious and details of diagnosis need not be recapitulated here but the existence of lesser degrees of hæmolysis is more difficult to determine and for this the services of the clinical pathologist may be needed Latent, that is to say subclinical hæmolysis can be determined by the fæcal estimation of urobilinogen the Ashby technique of trans fusing compatible but agglutinatively separate cells or by the use of tracer elements

Hypersplenism may affect all three of the circulating elements—erythrocytes leucocytes, and platelets—simultaneously, causing pancytopenia or it may affect only one or two of these elements If the red cells are chiefly affected anæmia results if the white cells leukopenia if the platelets, thrombocytopenia As the leukopenia is due mainly to reduction of the numbers of white cells

produced by the bone marrow and the predominant loss is of polymorphs the term neutropenia is often used

Attempts have been made to classify the blood dyscrasias in which hypersplenism plays a part on this basis and the following classification is modified from the one suggested by Coller *et al* (1950) more to suggest the possibilities of such a classification than to establish it

Red Cells (Anæmia)

1 Familial hæmolytic anæmia
2 Acquired hæmolytic anæmia
3 Latent (or occult) hæmolytic anæmia associated with other diseases—e g the leukæmias

White Cells (Neutropenia)

1 Primary
2 Felty s syndrome (leukopenia with splenomegaly associated with rheumatoid arthritis)

Platelets (Thrombocytopenia)

1 Primary or essential thrombocytopenic purpura
2 Purpura secondary to or associated with other conditions—e g sepsis drug poisoning and the leukæmias

All Elements (Pancytopenia)

1 Primary hypersplenism
2 Some examples of refractory or hypoplastic anæmia
3 Banti s syndrome
4 Associated with other splenomegalic disorders—e g Gaucher s disease and myelosclerosis

1 The Anæmias

Splenectomy is uniformly successful in eliminating the tendency to the hæmolytic crises of familial hæmolytic anæmia and may safely be recommended at an early age The youngest patient—and the severest case—in the author s experience was of a female infant nine months of age In older people in whom the disease has never been marked by crises the patient may come to operation because of symptoms provoked by gall stones, which invariably develop as age advances The stones are pigment stones and may be opaque to X rays Though usually small they may grow to the size of poker dice and be similarly facetted Changes in the gall bladder itself are usually not marked *If stones are discovered at operation for splenectomy they should be squeezed into fine granules and expressed via the cystic duct* or the gall bladder incised and the stones removed followed by repair of the gall bladder Only in older people in whom there is evidence of chronic cholecystitis or in whom the stones are of large size is cholecystectomy required

Occasionally in familial hæmolytic anæmia no abnormal fragility of the red cells can be demonstrated and no spherocytes found in the circulating blood In spite of this splenectomy is indicated

The effect of splenectomy for acquired hæmolytic anæmia is unpredictable In some it confers immediate benefit in others improvement follows after a prolonged latent period and in others it fails Before considering splenectomy every effort should be made to discover and eliminate the cause for the hæmolysis In cases where hæmolysis is severe the administration of A C T H or cortisone may be of value in causing a sufficient remission of the symptoms to permit splenectomy to be carried out without risk (*Lancet* 1951)

Latent hæmolysis is frequently found both in lymphatic and in myeloid leukæmia and where this can be demonstrated, splenectomy will have the effect of restoring the life of the red cell to a more normal duration and much of the patient s vigour though it does not otherwise influence the inevitable fatal course of these diseases As Berlin (1951) pointed out the benefit to be expected from splenectomy is usually proportional to the size of the spleen an observation which holds good for all types of hypersplenism

2 The Leukopenias

The term primary neutropenia was suggested for leukopenia associated with splenomegaly by Wiseman and Doan (1942) Though the exact nature of the condition is not understood it is probably related to reticuloendothelial hyperplasia The blood examination shows a degree of anæmia but a leukopenia out of all proportion to the red cell deficiency The lymphocytes may be relatively unaffected and may constitute well over 90 per cent of the total leucocytes The neutrophils however are few in number and degenerate The platelet count may be normal Splenectomy in this condition will result in a marked improvement in health with a return to a more normal level both in quantity and quality of the neutrophils

Allied to this condition is that of Felty s syndrome in which splenomegaly with neutropenia is associated with rheumatoid arthritis Splenectomy may lead to improvement both to the blood picture and of the rheumatic condition

3 Thrombocytopenia

Primary or essential thrombocytopenia usually responds well to splenectomy which should be practised in all but the less serious cases Patients subjected to splenectomy may never secure complete

normality but live in reasonable health, and are freed entirely from the danger of spontaneous bleeding If a poor response to splenectomy is obtained it is probable that a splenunculus or hidden accessory spleen (Curtiss and Movitz 1946) escaped attention at operation

The effect of splenectomy in thrombocytopenic purpura in adults particularly in those without a previous history suggesting that the disease is latent is variable On the whole it is more likely to be effective if the spleen is much enlarged when the effect may be dramatic In some there may be a period of some months *before* any appreciable effect upon the platelet count is observable

None the less in spite of the uncertainty of the ultimate outcome splenectomy should usually be advocated for a severe purpuric crisis of apparent spontaneous origin when it may be life saving It should be regarded as an emergency procedure and performed as soon as adequate preparation has been made Patients have probably lost lives as a result of delaying the operation until to morrow The same may be said of a purpuric crisis secondary to or symptomatic of conditions such as Hodgkin s disease It goes without saying that ascertainable causes of purpura such as sepsis drug poisoning etc should be eliminated, for which splenectomy should be considered only as a possible means of saving life during a severe crisis

4 Pancytopenia

A reduction of all cellular elements associated with splenomegaly but with no other abnormality has been described as a primary hypersplenism—but such a condition is extremely rare Nearly all examples of pancytopenia associated with splenomegaly are expres sions of a more generalized disease e g Banti's disease (which now must be considered under portal hypertension) some examples of refractory or hypoplastic anæmia Gaucher s disease sar coidosis Hodgkin s disease and finally those obscure conditions labelled myelosclerosis and myelofibrosis

The indication for splenectomy in such diseases depends entirely upon establishing the existence of hæmolysis and over the question of operation the surgeon will naturally act under the guidance of the hæmatologist

Technique of Splenectomy

However large the spleen adhesions are rarely encountered in operating for the conditions mentioned above, and splenectomy can safely be performed through the abdominal route T into

the chest is rarely if ever necessary An important step in technique, particularly when the spleen is large is to expose and ligature the splenic artery by entering the lesser sac through the gastro colic omentum before attempting to deliver the spleen

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CHAPTER XII

PORTAL HYPERTENSION

R MILNES WALKER

Relation to Banti's Syndrome

It is only recently that the significance of a high pressure in the portal circulation and the part it plays in what has been called Banti's Syndrome has come to be fully realized. There are a number of abnormal conditions under the title of Banti's syndrome and difficulties have arisen when cause and effect have been confused. Banti thought that in the disease which he described the *original source of the complaint was in the enlarged spleen* and fibrosis in the liver and consequent ascites occurred at a later stage. We now know that in some cases the liver is normal throughout the course of the illness and in these cases there is obstruction to the portal blood flow before it reaches the liver—pre hepatic obstruction—while in others the syndrome is caused by disease of the liver—intra hepatic obstruction. These cases suffer not only from the effects of the portal hypertension but also in varying degree from the effects of disturbance of liver function. Finally, there is a group in which the obstruction to the circulation is post hepatic i e in the hepatic veins (Budd Chiari syndrome) or the result of cardiac disease or constrictive pericarditis. Here the portal hypertension is subsidiary to the primary disease but this possibility must be borne in mind when making a diagnosis for in these cases treatment must be directed to the cause. One constant feature of all cases is enlargement of the spleen and then this organ may exert an abnormal influence on blood formation—a secondary hypersplenism—commonly taking the form of a leucopenia which when severe may be an indication for splenectomy.

Pathology

Pre-hepatic Obstruction Here there may be obstruction to the flow of blood in the portal vein itself or the obstruction may be in the splenic vein in which case the term splenic hypertension is more appropriate thus reserving the title portal hypertension for those cases in which the whole of the portal circulat[illegible] ffected

In many of these cases the obstruction is due to pressure on or invasion of the vein by a tumour and in such cases treatment is directed to the cause the same applies to thrombosis in these veins when it is part of a generalized disease Rarely the obstruction may be due to fibrosis the result of trauma or inflammation but in actual practice nearly all cases of pre hepatic obstruction causing portal hypertension for which treatment is required are congenital in origin either a stricture or atresia of the vein or more commonly the condition known as cavernomatous transformation of the portal vein in which the vein is replaced by numerous dilated and tortuous channels

Intra-hepatic obstruction is caused either by fibrosis in the liver or pressure resulting from fatty infiltration or regeneration nodules, and there is evidence to suggest that in Great Britain many of these cases follow an attack of acute infective hepatitis or homologous serum jaundice There is no evidence (Gerrard 1952) that it follows hæmolytic disease of the new born Disturbance of liver function varies from case to case—some patients with grossly cirrhotic livers and severe deterioration of liver function have normal portal pressures while others with only slight fibrosis usually show no evidence of damaged liver function by the usual biochemical tests but may have very high portal venous pressures The rate of progress of the disease and the portal venous pressure probably depend on the distribution rather than the amount of fibrosis in the liver (Walker 1952) The gross pathology of the liver is extremely variable there may be a fine fibrosis which does not distort the shape of the liver but gives it a granular appearance and a consistency which is only slightly firmer than normal In such cases the portal pressure is high and both the spleen and the splenic vein are much enlarged histologically there is fibrosis in the portal tracts and often fine fibrous strands linking up the portal tracts with each other Liver function tests show no abnormality At the other extreme is the hobnail liver grossly distorted in shape, hard in consistency and with much fibrous tissue causing the parenchyma to be split up into isolated islands The spleen is not so greatly enlarged but there are likely to be signs of defective liver function In general this type occurs in older patients, but the clinical evidence does not suggest that it is a later stage of the former type it represents post necrotic scarring following some condition which has caused destruction of liver tissue The presence of ascites however is always evidence of interference with liver function for high portal pressures may be present without ascites though such a raised pressure may aggravate ascites already due to

liver dysfunction Distinct from these is a group in which the liver is swollen and congested with little or no fibrous tissue Finally certain specific diseases of the liver e g hæmochromatosis and schistosomiasis may cause portal hypertension

Portal Venous Pressures

The normal portal venous pressure in man is between 100 and 160 mm of water and the factors which influence it are imperfectly known If during the course of an operation the portal vein is occluded the pressure rapidly rises to about 600 mm of water Cases have been recorded (Child *et al* 1952) in which the portal vein has been ligatured at operation for resection of the pancreas but the follow up was short and in most of them a gradual obstruction of the vein had already been caused by the tumour In dogs sudden ligature of the portal vein causes rapid death but gradual occlusion of the vein induces the development of an adequate collateral circulation and no evident portal hypertension results (Douglas *et al* 1951) In man life is possible after gradual but complete occlusion of the portal vein by thrombus but in such cases the portal pressure is dangerously high and the risk of hæmorrhage is great

Collateral Circulation

The effect of portal hypertension is to open up the collateral vessels which normally exist between the portal and systemic circulations These are all beneficial to the patient with the exception of the varices in the submucous layer of the œsophagus and cardiac end of the stomach in this situation they are liable to rupture and cause serious hæmatemesis or melæna as the mucosa over them becomes thinned and is readily damaged either by trauma of food particles or erosion by gastric juice In long standing cases the appearance as seen through the œsophagoscope suggests that in time epithelial hypertrophy may ensue for the varices may be covered by an opaque white epithelium

Collateral veins in the falciform ligament also become enlarged (Fig 46) and occasionally there is one single large vein coming from the left branch of the portal vein and penetrating the linea alba The flow in this vein may cause a murmur and palpable thrill this constituting the Cruveilhier Baumgarten Syndrome (Fig 47) The enlarged veins in the anal canal causing internal hæmorrhoids may draw attention to the patient s condition by bleeding but the loss of blood from this cause is rarely serious

When portal hypertension exists there is a liabilit bosis



FIG 46 Sub cutaneous portal systemic anastomoses Infra red photograph



FIG 47 Sub cutaneous veins in a case of Cruveilhier Baumgarten syndrome

in the portal vein and its tributaries so that a pre hepatic as well as an intra hepatic obstruction exists and these veins may be rendered useless for an anastomosis

Clinical Aspects

Clinically these patients present with bleeding from œsophageal varices portal hypertension causing about 10 per cent of all cases of serious hæmatemesis Patients with cirrhosis of the liver may have ascites but the portal pressure is not raised in all cases of cirrhosis The attacks of hæmatemesis may follow each other in rapid succession though some patients may go for many years in apparently perfect health between successive attacks but when gross cirrhosis is present the condition is serious for half the patients die within a year of their first bleeding The spleen is always enlarged and usually palpable and dilated veins in the abdominal wall may be visible When hæmorrhage occurs the blood may all pass down the alimentary canal and cause melæna and the patient may complain only of lassitude, faintness or pallor When the

obstruction is pre hepatic the liver is normal but in the intra hepatic obstruction group the liver is unduly firm and may be palpable

Diagnosis rests pre eminently on the demonstration of varicose veins in the submucous layer of the œsophagus or cardiac end of the stomach for which a barium swallow is of the utmost value the varices showing as rounded filling defects in the lower part of the œsophagus or in severe cases extending up to the cervical portion If the appearance on X ray is not conclusive an œsophagoscopy should be performed and by this method the blue varicosities can easily be seen and the level to which they rise determined In the absence of œsophageal varices a diagnosis of significant portal hypertension can be excluded Many cases can be diagnosed before they have their first hæmatemesis because an enlarged spleen is found either on routine examination or if the patient seeks advice on account of lassitude or other vague symptoms Thus a search for œsophageal varices should be made in any patient with an enlarged spleen which is not otherwise readily accounted for

The diagnosis between intra and extra hepatic obstruction is not always easy If there has been a previous history of jaundice or if there is evidence of disturbance of liver function the case can be presumed to be intra hepatic My experience of 10 cases of extra hepatic obstruction is that in all of them the bleeding commenced before the age of twenty Portal venography, to be described later may be helpful in localizing the site of the obstruction As already mentioned thrombosis of the portal vein may add an extra hepatic obstruction in a case of intra hepatic disease

Investigations

When the diagnosis has been established there are certain investigations which are necessary before the best course of treatment can be advised

Liver Function Tests Some idea of the state of the liver can be gained by clinical examination muddy complexion spider nævi and ascites indicate a defective liver but biochemical tests are helpful and as a routine we make use of differential serum protein estimations alkaline phosphatase level thymol turbidity and flocculation tests In some clinics much reliance is placed on the bromsulphathalein excretion rate If the serum albumen is below 2 5 gm per cent or is lower than the globulin level or if any of the other tests show gross abnormality caution in recommending any major surgical procedure must be exercised The results of

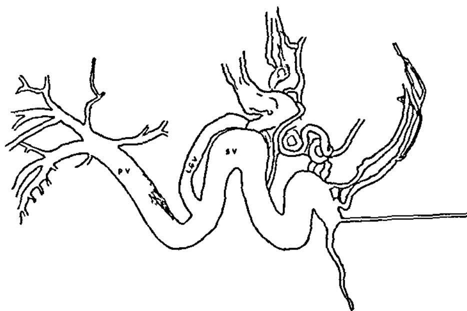


Fig 48 Portal venogram by intra splenic injection showing little filling of the liver but filling of the left gastric vein and œsophageal varices

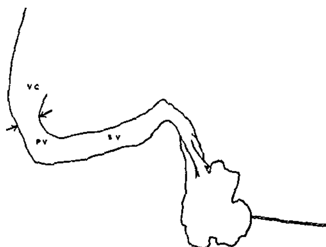


Fig 49 Portal venogram by intra splenic injection six months after end to side porta caval anastomosis showing no filling of the collaterals but some filling of the inferior vena cava Arrows indicate site of anastomosis

trying to improve the liver function by a high protein low salt diet have been disappointing

Blood Count This investigation which must include a platelet count, is necessary to exclude any effects of hypersplenism, a mild leukopenia is not of importance but severe anæmia or a low platelet count need correction and may be evidence of hypersplenism indicating that a splenectomy should be undertaken as part of the treatment

Intravenous Pyelogram If a spleno renal anastomosis is contemplated this should be done to ascertain the position and function of the kidneys

Portal Venography This valuable method of demonstrating the site of obstruction in the portal venous system by injection of opaque fluid into one of its tributaries has been used with great advantage, but has the drawback that it can only be carried out at laparotomy Recently the investigation has been widened in its scope by injection of the opaque medium into the substance of the spleen This can be done under local anæsthesia, and gives excellent outlines of the splenic and portal veins (Figs 48 and 49) (Leger 1951, Boulin *et al* 1951 Dreyer and Budtz Olsen 1952) It may not be entirely without risk so it is not advised as a routine we have had one case of rupture of the spleen requiring splenectomy three days after a portal venogram in which the injection was made into a normal spleen at operation for another condition It should be undertaken if the case is suggested to be one of extra hepatic obstruction or if there is reason to suspect that the portal vein may be thrombosed secondary to cirrhosis of the liver (Walker *et al* 1953)

Peritoneoscopy In a small group of cases this examination is useful in order to study the gross pathology of the liver particularly if any operative procedure is contemplated when ascites is the main symptom It is also of value in estimating the size of the spleen, e g in fat patients when palpation is difficult

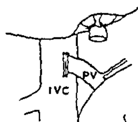
Liver puncture biopsy has little place in the investigation of portal hypertension itself but may be useful if one of the less common causes of hepatic fibrosis e g *hæmochromatosis* or schistosomiasis is suspected

Every case of suspected portal hypertension should, therefore have a barium swallow liver function tests and a blood count while other investigations may be called for in particular cases

Surgical Treatment

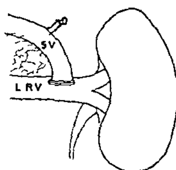
The aim of surgical treatment of portal hypertension is to prevent death or serious incapacity from hæmorrhage as a result of rupture

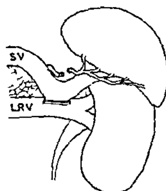
of œsophageal or gastric varices In the majority of cases the bleeding comes from the œsophagus where the pressure in the lumen is lower than in the stomach and the varices are less well supported and more exposed to trauma Surgical measures are advised in younger patients with good liver function if large varices are present even if bleeding has not already occurred There is no conclusive evidence that ascites is benefited by surgical measures the formation of ascites in patients with hepatic fibrosis is such a variable





PORTA-CAVAL ANASTOMOSIS





SPLENO RENAL ANASTOMOSIS

FIG 50 Types of portal systemic anastomoses

symptom—it may disappear when no treatment whatever is undertaken—that it is very difficult to assess any results of particular forms of therapy It is always an indication of severe liver damage and major surgery in these cases is attended by a higher mortality

There are two methods by which attempts are made to reduce the risk of hæmorrhage

(1) By a venous shunt to reduce the portal venous pressure, and
(2) By diverting the portal blood from these varices or excising the varix bearing area

Both theoretically and in practice it seems that the former method is the most effective, but the venous anastomosis must be between a large vein of the portal system and a large low pressure systemic vein (Fig. 50). Beswick and Butler (1951) have argued that venous shunts are ineffective because patients may die of hæmorrhage even when a large natural collateral circulation as big as many shunts made by the surgeon has formed in the falciform ligament; this is of little use, however, because it does not end in a large low pressure systemic vein and so is not comparable with the artificial shunts. As in obstruction elsewhere the nearer the relief is to the site of the obstruction the more effective it is; thus the portal vein is the most valuable for such a shunt. If it is abnormal, as in extra-hepatic obstruction, an alternative vein must be sought and the splenic is the largest available. Thus an anastomosis between the portal vein and the inferior vena cava or between the splenic vein and the left renal vein are most commonly made. Other veins have been used, but they are usually too small and the openings are liable to thrombose.

Before any operation for a venous shunt is made it is important that adequate blood should be available for transfusion; the danger lies not in loss of blood from the veins being used for the anastomosis (though there should be means of rapid replacement of blood in such an accident as a clamp slipping), but in the ooze of blood from the thin walled collaterals which may be encountered during the approach to the main veins.

Portal-systemic Shunts: Porta-caval Anastomosis

A thoraco-abdominal incision gives much the best access for this operation; the patient lies tilted towards his left side and the incision made in the right side along the line of the ninth rib from the posterior axillary line to a point just in front of the costal margin. The rib is resected and the costal cartilage incised longitudinally with a scalpel which allows for good repair of the costal margin during closure. Both the pleura and peritoneum are opened along the line of the skin incision and then the diaphragm split in the direction of its fibres as far back as the bare area of the liver. This allows the liver to be displaced upwards and gives good access to its under surface. Vascular adhesions may make the next step difficult, but the peritoneum on the outer side of the upper part of the duodenum is incised and the duodenum displaced forwards; the incision in the peritoneum is carried upwards along the anterior margin of the foramen of Winslow to the hilum of the liver and laterally along the lower margin of the coronary ligament. The

portal vein is now looked for in the lesser omentum If the common bile duct comes into view it is retracted forwards, but it may not be exposed The portal vein usually can be separated easily from the surrounding connective tissues but if it is adherent it indicates that there has been some thrombosis in it One or two tributaries may be found entering the portal vein from the left side and they should be divided between ligatures otherwise they are liable to tear out of the portal vein

A decision must now be made regarding an end to side or a side to side anastomosis I prefer to divide the portal vein high up and make an end to side anastomosis to the inferior vena cava This type of anastomosis causes less distortion of the portal vein and a more direct line of flow into the vena cava and I believe is less liable to thrombosis There is no evidence that after an adequate side to side anastomosis any blood continues to flow up the portal vein into the liver, in fact it may even flow in the reverse direction in any case this blind alley is likely to become thrombosed and the thrombus may extend down to and occlude the anastomosis This cannot happen if an end to side anastomosis has been made The portal vein should if possible be freed up to its division into right and left branches so that separate ligatures can be placed on each branch as recommended by Stock (1951) When at least 3 cm of the portal vein have been isolated attention is paid to the vena cava and this must be exposed from the level of the right renal vein up to the liver and the whole of its anterior wall uncovered and cleared of adventitia

Everything is now ready for the placing of clamps and making the anastomosis A Blalock clamp is placed on the portal vein as low down as possible and ligatures on the upper end preferably on the two main branches The vein is then divided just below the upper ligatures and washed out with citrate solution or heparin A lateral clamp is now put on the inferior vena cava I have found one or other of Brock s clamps used for the atrial appendix in mitral valvotomy adequate for this purpose An incision equal to the diameter of the portal vein is made in the inferior vena cava and anastomosis carried out with a single layer of everting continuous silk sutures commencing at the upper end There is no need to excise an ellipse of the wall of the vena cava When complete the inferior vena cava clamp is removed first and any small leaks nearly always close after slight pressure occasionally an additional stitch is necessary When the portal vein clamp is removed the flow of blood into the inferior vena cava can often be seen through the thin wall of the latter A drain is inserted down to the site of

anastomosis and brought out below the costal margin and usually retained for twenty four hours The diaphragm is repaired and the chest closed without drainage after full expansion of the lung

Spleno-renal Anastomosis

This is combined with splenectomy and is most conveniently performed through a left thoraco abdominal incision In removing the spleen great care is taken of the splenic vein there is no need to isolate a long length of this vein from the tail of the pancreas but the two together must be mobilized and when it comes to an anastomosis a Brock s mitral valvotomy clamp can be put on them both this avoids freeing much of the vein which is very liable to injury in the process and about 1 5 cm of free vein is adequate for making the anastomosis

The renal pedicle is now dissected out and here at least 3 cm of the vein must be isolated it is not necessary to put a temporary clamp on the renal artery unless the kidney becomes grossly engorged when the vein is clamped and in any case it should not be kept on for more than thirty minutes Usually a Blalock clamp on the proximal end of the vein and controlling ligatures on the distal end or its two main tributaries is the most convenient, while either a bull dog clamp on the splenic vein or a Brock mitral clamp on the vein and tail of pancreas combined are satisfactory The end to side anastomosis is made with the usual technique making a transverse incision in the renal vein

Other sites for a portal systemic anastomosis have been used, but the only one requiring mention is a lateral anastomosis between the superior mesenteric vein and inferior vena cava (Blakemore 1951)

If there is difficulty in bringing the veins to be anastomosed together a vein graft may be inserted between them in the only case when I have done this thrombosis has probably taken place for there has been recurrence of hæmorrhage

Operations on Œsophageal Varices

Operations which aim at diverting blood from the œsophageal varices consist in the division of the large tributaries in the lesser omentum and in the wall of the stomach or œsophagus Access is difficult from the abdomen owing partly to the frequent presence of vascular adhesions so a left thoracotomy is the best line of approach

The pleura is opened through the ninth rib bed Large veins are usually present on the outer surface of the œsophagus and the

veins accompanying the phrenic nerve and some of the lower intercostal veins may be dilated Œsophago gastrectomy, as recommended by Phemister and Humphreys (1947) is a radical operation but such a drastic procedure may not be necessary and has the disadvantage of the œsophagitis which so often follows

The simplest procedure is œsophageal transection—that is to say division of the œsophagus at the level of the hiatus and resuture after ligation of the larger varices—but this does not necessarily relieve the varices in the stomach Alternatively gastric transection as advocated by Tanner (1950)—best carried out by a trans thoracic approach splitting the diaphragm—may be considered but it is also important to divide the large veins on the lesser and greater curvature of the stomach

Other measures are ablation of the submucous varices by sutures after opening the œsophagus without dividing it right across as advocated by Boerema (1949) and by Crile (1950) ligature of all veins entering and leaving the thoracic œsophagus (Allison 1950) or mediastinal packing to promote extra œsophageal vascular adhesions (Garlock and Som 1950) No long series of cases treated by any of these methods has yet been reported and they must be regarded as experimental

Injection of the varices with sclerosing solution through an œsophagoscope has been employed (Crafoord and Frencker 1939) but the results are disappointing In the same way attempts to reduce the blood entering the portal circulation by ligature of the splenic artery or by splenectomy are of no lasting value in portal hypertension and splenectomy is indicated only when the obstruction is in the splenic vein alone (splenic hypertension) In portal hypertension splenectomy alone is strongly contra indicated as it may destroy the only vein suitable for a portal systemic anastomosis

A new approach to the problem has been introduced by Rienhoff (1951) and by Berman *et al* (1951) in the use of hepatic artery ligation for this condition with or without splenic artery ligation The basis of this is the fact that ligature of the hepatic artery does bring about a fall in portal blood pressure probably because in advanced cirrhosis there is a much increased anastomosis between the hepatic artery and portal vein branches in the portal tracts so that some of the hepatic artery pressure is transmitted to the portal system The risk of hepatic necrosis is less than occurs when the hepatic artery is accidentally ligatured in patients with normal livers but fatalities from this cause have occurred particularly if the artery is ligatured above its gastro duodenal branch It may have some value in treating advanced cirrhosis with ascites, but

at present a venous shunt is preferable in those cases with good liver function who have had serious hæmorrhages

Results of Surgical Treatment

There are great difficulties in assessing the results of treatment of portal hypertension because many patients go for long periods between successive bouts of hæmatemesis and ascites is a symptom which may have long spontaneous remissions All working in this field agree that repeated hæmorrhages are very likely to prove fatal and that they are an indication for surgical treatment , there is less enthusiasm for operating when ascites is present and both the immediate mortality and late results are not so satisfactory The evidence suggests that when a large venous shunt has been made and it remains patent the danger of serious hæmorrhage is eliminated

The risk of operation itself depends very much on the condition of the liver for the most common cause of mortality is liver failure

Except for the performance of portal systemic shunts there are no figures available on which an opinion of the results of surgical treatment can be formed In my own series of patients 41 venous anastomoses have been performed on 40 patients They fall into two groups—those performed before and those since January, 1950 when it was realized that a large opening was necessary and that adequate access to the portal vein could only be obtained through a thoraco abdominal approach

	Before 1950		After January 1950		Total	
	Cases	Operative Deaths	Cases	Operative Deaths	Cases	Operative Deaths
Porta caval anastomosis	2	0	22	2	24	2
Spleno renal anastomosis	11	3	4	0	15	3
Other vessels	2	0			2	0
Total	15	3	26	2	41	5

The two operative deaths in patients who had had porta caval anastomoses were due to liver failure both had defective liver function before operation Two patients in the group operated on before 1950 subsequently died one—in whom the porta caval anastomosis became thrombosed—of further hæmorrhage and the other of hepatic failure One patient operated on since 1950 has died of a subsequent hæmorrhage in spite of the fact that his anastomosis was patent but one in whom a vein graft was used has had further bleeding

Blakemore who has the largest experience of these operations and has carried them out on some patients with severe liver damage has created shunts 166 times on 160 patients with a mortality of 18 per cent but in the last 107 cases the mortality has been only 8 4 per cent

Stock working in Hong Kong—where cirrhosis is usually due to nutritional causes and ascites rather than hæmorrhage is the prominent symptom—reports encouraging results after end to side porta caval anastomosis but advocates a preliminary splenectomy because in this type of case splenic vein thrombosis is a common complication and adds a local hypertension to the portal obstruction

Gastric or œsophageal transections have been carried out without mortality on 16 patients on whom a venous shunt was not practical during the last three years Recurrence of bleeding has taken place in 5 of them but so far there have been no subsequent deaths from this cause

There is no doubt that experience of the operative measures employed brings improvement in the results and that a reasonably low mortality can be attained by the careful assessment of each individual patient but the operation should not be delayed until liver function has deteriorated or the main veins of the portal system are occluded by thrombosis

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CHAPTER XIII

REGIONAL ENTERITIS

CROHN'S DISEASE

HAROLD C EDWARDS

Introduction

THE suggestion that Crohn's disease is of a sarcoid nature is no longer tenable Great interest attaches to the work of Chess and



FIG 51 Photograph of opened terminal ileum of a dog sacrificed after three weeks of sand feeding and after receiving intravenous injections of laboratory strains of non specific bacteria Note mucosal ulceration This dog developed a bloody diarrhœa

[*By courtesy Dr Warren H Cole and the Editor Surgery Gynæcology and Obstetrics*

his colleagues (1950) who by feeding dogs on talcum powder and on finely divided sand and rats on sand for a sufficient length of time and in sufficient quantity produced changes in the terminal ileum similar to those present in Crohn's disease in the human being (Fig 51) Talc powder seemed to be more pathogenic than sand Their conclusion that the ingestion by the ileal mucosa of insoluble particles of matter has an ætiological bearing has given rise to the suggestion that the excessive use of modern tube tooth paste may possibly be a causal factor

Clinical Features

Crohn's disease varies greatly in its manifestations. It may present in the form of an insidious fibrotic process without gross lymphadenoid change, or it may develop rapidly, with emphasis chiefly on mucosal changes, accompanied by great swelling of the lymphatic glands and causing an acute febrile illness. Its behaviour follows no formal pattern. It may progress continuously and with increasing momentum, or fitfully, with periods of relative quiescence. It may lie dormant for many years—it has been known to recur twenty years after apparent cure by operation. It may resolve completely, or with a legacy of permanent fibrotic changes in the bowel which is not incompatible with good health. Finally, its course may be profoundly influenced by emotional stress.

Though Crohn's disease may affect the œsophagus, the stomach, the duodenum or the jejunum, it is nearly always situated in the terminal ileum. Very occasionally, particularly in older people, it may commence in the colon or recto-sigmoid. Usually when present in the terminal ileum it ceases abruptly at the ileo-caecal valve, but in the more acute onslaughts it may soon spread distally to affect the ascending colon, and a condition of ileo-colitis may result which is hard to distinguish from that of ileo-colitis which is regarded as being one of the types of ulcerative colitis.

Age Incidence

The disease is essentially a disease of young men and women, though older people are not immune. In the latter the disease is usually well localized, presenting a clinical picture indistinguishable from an encircling cancer; a satisfactory outcome of excision may then confidently be expected.

The onset of symptoms is often in the late teens or early twenties. Most of the patients start their downward alimentary career before the age of twenty-five, most often with the removal of a so-called grumbling appendix, or with the development of a peri-anal abscess. One of the author's patients had his gall-bladder removed for cholelithiasis at the age of eighteen.

Mode of Onset

Knowledge of the existence of the disease often awaits laparotomy, for symptoms simulating those of appendicitis of varying degree are present in at least half the patients, and indeed in the majority of the youthful sufferers. It is for this reason that patients with Crohn's disease come under the care of the surgeon rather than that of the physician.

When the abdomen is explored for acute symptoms, the terminal ileum may be found reddened and oedematous with swelling of the mesenteric glands—acute ileitis This condition may resolve completely, or may progress to the characteristic syndrome of Crohn s disease which was the case in four of nine patients in the author's series

The condition of mesenteric lymphadenitis sometimes revealed at operation in young children, in which the terminal ileum may be pink from congestion, has probably a different ætiology It is rarely if ever a precursor of Crohn s disease

In only one of eleven patients in the author s series for whom exploration had been undertaken for vague abdominal symptoms was the appendix found to be involved This patient's surgical history is as follows at eighteen years, fistula in ano , at twenty, recurrence of fistula , at twenty one, appendicectomy , at twenty three ileo colostomy followed by resection, and death four months later Here was an example of the fulminating type of the disease

Of ten patients, appendicectomy preceded any recorded changes in the ileum in five It is important not to remove the normal appendix if Crohn s disease is present, for this definitely increases the risk of fistula formation

Diagnosis

A discernible clinical pattern emerges from the study of many case histories despite the vagaries of the disease A young adult, usually of spare build active habits and an alert mind, starts to suffer mild abdominal discomfort associated with diarrhœa The appetite becomes impaired there is perhaps a little weight loss and in female patients the menses may become irregular The patient tires easily suffers from bouts of depression and powers of concentration diminish Apart from a small degree of anæmia and perhaps a raised E S R with a little rise in evening temperature, investigation including X ray is negative There is some danger at this stage especially if the patient is a young woman, of diagnosing "nervous dyspepsia" Later, when symptoms become more insistent a mass may develop in the lower abdomen for which exploration is undertaken

Some Leading Symptoms

Diarrhœa is nearly always present especially in the young subject and though varying in severity from day to day is persistent In most cases no deficiency of fat metabolism is to be found Where such a deficiency is present it usually connotes

extensive involvement of the ileum and should be a deterrent to surgery

Anæmia is usually microcytic and of slight degree and tends to correspond in severity with the diarrhœa One of the author's patients developed a megaloblastic anæmia following a short circuit operation (not exclusion) The anæmia improved after an ileo hemicolectomy Later this patient at the age of thirty seven developed cancer of the lower end of the œsophagus from which she subsequently died

Peri anal abscess is too common an antecedent of Crohn's disease to be regarded as purely coincidental and if such an event is associated with vague abdominal symptoms in the young subject the presence or imminence of Crohn's disease should be suspected It occurred in six of the author's patients before the diagnosis of Crohn's disease was established the ages varying between twenty one and twenty six The cause of this peri anal infection is not clear but it is probably to be regarded more as a local complication of persistent diarrhœa than as due to any specific cause

Fistula formation may follow operations directed to the cure of the disease e g short circuit or resection or it may precede such activities In either event it almost always develops through the scar of a previous operation or drainage wound Rarely it may be peri anal (Crohn 1949) In only one case in the author's series did a fistula develop spontaneously through the virgin abdominal wall The presence of a fistula is to be regarded as an indication for operation for spontaneous healing is rare Operation limited to excision of the fistulous track down to the bowel is however, likely to be ineffective merely adding yet one more operation to the patient's score

Internal fistulæ into neighbouring bowel particularly the ileum or the sigmoid colon are of frequent occurrence Rarely an ileo vesical fistula may form giving rise to cystitis with pneumaturia

A Familial Factor ?

Many examples of the disease occurring in members of the same family suggest the possibility of genetic or environmental pre disposition The author's series of forty seven patients include two brothers ages at operation being twenty two and twenty seven and identical female twins ages at operation being twenty seven and thirty In the latter operation findings were identical, except that one had a fistula Both were treated by resection and both regained full health, being well thirteen years and ten years respectively since operation

Kinship with Ulcerative Colitis and Tuberculosis

There is undoubtedly a kinship between ulcerative colitis and Crohn's disease although their clinical pictures differ so strikingly One essential pathological distinction is the tendency to fistula formation in Crohn's disease and which is not shared by ulcerative colitis

The kinship between the two is none the less a very real one for what starts as a characteristic example of Crohn's disease of the ileum may spread to produce changes in the large bowel equally characteristic of chronic ulcerative colitis

Conversely, para colic lymphatic glands in ulcerative colitis cases may contain non caseating giant cell systems typical of those found in mesenteric lymphadenitis associated with Crohn's disease

Tuberculous enteritis may cause changes in the terminal ileum identical at first sight with those of Crohn's disease, and can be distinguished from the latter only by the presence of tubercles on the peritoneal coat and by guinea pig inoculation

Treatment

The results of surgery in the treatment of Crohn's disease are disappointing—even dismaying Whatever operative method be adopted the frank recurrence rate within a few years is within the region of 50 per cent and only a proportion of the remainder regain a normal bowel habit This estimate is based upon the author's own experience and upon reports both published and unpublished emanating from various centres in the United Kingdom and the United States of America

The two accepted forms of surgical treatment are ileo hemi colectomy and exclusion ileo colostomy Most surgeons, with the notable exception of the Mount Sinai Hospital group New York have a preference for excision In the author's experience the success of operative treatment is related directly to the age of the patient and to the chronicity of the disease The older the patient the more satisfactory the result This applies in particular to excision which is best accomplished in one stage with end to end or end to side ileo transverse colostomy If this operation is practised in the very young subject in whom the history of illness is short though the main symptoms may be eliminated, diarrhœa is very likely to persist and full health is rarely regained Frank recurrence is common The same applies to exclusion ileo colostomy though on occasion especially when employed when multiple fistulæ are present and the patient is in a very ill condition the immediate benefit to health of this procedure may be dramatic

Simple side to side anastomosis may yield an occasional success, but usually, at best, causes only temporary abatement. The author has reason to believe that it may sometimes accelerate, or at least favour, spread of the disease to the large bowel. He shares the opinion that the essential of any operative treatment must be transection of the ileum well above the disease so that direct spread upwards from the affected portion is foiled.

The two stage operation has little to recommend it as a planned procedure though it may be an operation of necessity in those patients who do not improve after exclusion ileo colostomy.

Vagotomy appears to have the effect of diminishing the degree of diarrhoea thereby causing a general improvement in health sufficient to make further surgery justifiable at a subsequent date. X ray treatment has been explored (Eggers 1933, Kiefer and others 1950) but there is little evidence of its efficacy though it may be worthy of trial in those patients who have recurred after either resection or short circuit or in whom the disease is widespread, and attended with fistulae.

In view of these experiences the question must be posed "Is Crohn's disease in its early stages in young people a surgical disease?" In answering this question attention must be paid to two known facts.

(*a*) Under certain circumstances Crohn's disease may resolve—or at least become inactive dying away to leave only fibrotic changes in the subserous coats.

(*b*) Spontaneous fistulae—that is fistulae through the unoperated abdomen—are excessively rare. The weakness here in clinical work is that diagnosis usually awaits exploration. Under such circumstances the only way of reducing the risk of fistulae is to resist any attempt to interfere with the bowel in the young patient. The appendix must be left.

In the light of this knowledge the surgeon would do well to consider the possibilities for the young patient of treatment in the first instance by complete rest in bed and a high protein diet. The period of rest enjoined must be indefinite but should continue until all symptoms pass away or until it is evident that the disease progresses in spite of this *régime*. The patient and relatives must be impressed with the overriding need of obtaining resolution. The disease as tragic experiences with many patients has shown is as grave a matter as tuberculosis, for which the need for prolonged rest is so readily accepted.

Summary of Treatment

For young subjects complete bed rest on a high protein diet. Surgery is indicated in older people in whom the disease is well localized, and for those patients who do not respond to medical treatment.

The operation of choice is ileo hemicolectomy, performed in one stage. Exclusion ileo colostomy is preferred for the more diffuse lesions, where the radical operation may carry considerable risk, in the treatment of recurrence, and in the very young subject in whom attempt at surgical relief is impelled by failure of medical treatment.

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CHAPTER XIV

THE COLON

HAROLD C EDWARDS

ULCERATIVE COLITIS

CONTINUED failure of medical treatment greatly reduced risks of operation and improvements in ileostomy appliances have all contributed to an extended use of surgery for the cure of chronic ulcerative colitis Moreover in the treatment of the typical disease in which the whole colon and rectum are involved there is an increasing tendency to attempt excision of the whole colon or at least the major portion of it as a primary procedure In some clinics the practice has been extended to include the rectum at the same session Such a radical approach—and the operative risk of subtotal colectomy is not significantly greater than that of ileostomy alone—has very many advantages over the two or three stage operation of which ileostomy is the first step The discomfort to the patient is reduced incomparably the toxic effects of the diseased colon are immediately eliminated the ileostomy is more readily developed into an adequate excretory organ in the absence of the colon and the surgeon is not embarrassed at colectomy by the increase in body weight which may often follow upon a successful preliminary ileostomy

This conception has developed not only because it has been established that the patient suffers no appreciably greater risk from the primary radical operation than he would from ileostomy alone but also from the abandonment of the last lingering hopes entertained for so long that ileostomy alone might result in sufficient restoration to health of the colon to enable its eventual closure with restoration of continuity The number of cases in which this desirable sequence has been followed is indeed too small to influence the main contention

Ætiology and Medical Treatment

Meyer and others (1949) have shown that the mucolytic enzyme lysosyme is present in increased amount in the stools in ulcerative colitis and diminishes with clinical improvement and uce that

excess of lysozyme or a similar enzyme may be an ætiological factor Sammons (1950) however thinks that lysozyme in the fæces is derived from pus cells and that it is not of ætiological significance Further researches are being undertaken In treatment hog duodenum (Streicher and others 1949) and crude extract of intestinal mucosa (Friedman and Haskell 1948) have been used to some advantage in early cases and there is evidence that the physician is paying more attention than hitherto to the undoubted psychological factors which attend the onset of the disease, and its exacerbations once it is established Of more immediate interest to the surgeon is the use of ACTH and cortisone Trial of these two hormones either alone or in sequence has led in a proportion of cases to improvement in appetite and well being to a fall in temperature, and to a lessening of pain and diarrhœa Their use however is attended by danger of complications specifically due to them such as perforation of a hæmorrhage from an unsuspected peptic ulcer and silent perforation of the colon itself The chief use of these substances appears to be in the treatment of the fulminating case for it is a safer alternative despite the risk of complications to an emergency ileostomy, which is so frequently fatal Lahey (1951) recorded remission of the acute phase in 21 of 28 cases treated with ACTH

Vagotomy

It is with some hesitation that one includes mention in "Recent Advances of vagotomy as a treatment for chronic ulcerative colitis None the less there is considerable evidence that division of both vagus nerves may cause a significant amelioration of symptoms if performed early in the history of the disease, before extensive fibrosis has developed in the colon This amelioration is, according to Eddy (1951) particularly striking after vagotomy performed for the fulminating form of the disease The benefit alleged to be conferred by this operation is however difficult to comprehend except in those cases in which the ileum is involved for it is doubtful whether any branches of the vagus reach as far as the colon Further proof of the value of the operation will be needed before it can be accepted as a worthwhile procedure

Predisposition to Cancer

It has finally been established beyond reasonable doubt that chronic ulcerative colitis predisposes to cancer Published figures of the incidence of cancer as a complication vary from 1 to 10 per cent, but the lower figure is certainly an understatement probably

due to failure to follow up the cases for long enough, for Shands and others (1952) found that the average duration of symptoms of ulcerative colitis in seventy three cases before cancer supervened was over fifteen years

A disturbing feature is that cancer secondary to ulcerative colitis usually appears in an intensely malignant form It grows rapidly and metastasizes early and is frequently multicentric in origin The average age of the patients is considerably less than that of those who develop cancer without previous bowel disease, and because of the disarming symptoms of chronic colitis its presence may not be suspected until it has become well advanced The experience of Counsell and Dukes (1952) is in fact, that the patient is usually incurable by the time the presence of cancer is realized In any event the prognosis is very bad

These facts are weighty arguments in favour of total removal of the colon and rectum in the surgical management of chronic ulcerative colitis

Right-sided Colitis

In its usual form ulcerative colitis appears to begin in the rectum or the distal colon and to spread throughout the colon often stopping abruptly at the ileo cæcal valve In a minority of cases however estimated at about 5 to 8 per cent of the total number, the disease affects mainly the right half of the colon the left half being apparently normal When found in this situation the disease appears to pay little respect to the ileo cæcal valve for the ileum is also frequently involved Brooke and Cooke (1951) in fact, think that the disease in this form may actually start in the ileum and spread to the colon instead of the reverse process because a history of steatorrhœa in some of their patients ante dated any symptoms of disease in the colon itself These workers rightly stress the importance of careful radiological investigations of the ileum when the brunt of the disease is shown to be in the cæcum and ascending colon before operation is decided upon This consideration of course also applies to chronic ulcerative colitis in which the whole colon is involved for although the disease seems usually to stop at the ileo cæcal valve it sometimes spreads into the ileum—and not merely as a terminal event for Macready and others (1949) obtained microscopic evidence of involvement of the ileum in nine of 103 patients with a short history of colitis

Brooke and Cooke suggest that right sided colitis should be regarded as a separate disease demanding separate consideration of treatment and feel that ileostomy is definitely contra indicated

Ileostomy alone, however, should never be considered in the treatment of a disease which is limited, as far as the colon is concerned, to its right side for the condition is amenable to surgical excision with restoration of continuity by an end to end anastomosis between the ileum and the residual healthy distal colon The note of caution expressed by Brooke and Cooke is, however a timely one and if there is clinical evidence of steatorrhoea or radiological evidence that the ileum is involved, then it is probable that surgical treatment is contra indicated altogether

Indications for Surgical Treatment and its Scope

Surgery finds its best application in the treatment of chronic intermittent ulcerative colitis and should be undertaken during a period of relative quiescence None will dispute that the following complications of ulcerative colitis are either absolute or very strong indications for surgery stricture, perforation, cancer, recurrent severe hæmorrhages recurrent peri rectal abscess, pyoderma arthritis It is however impossible to lay down any exact ruling for the employment of surgery for the uncomplicated case for the effects of the disease vary so greatly in different patients, and for each the decision to operate must rest upon its own merits Three guiding principles may nevertheless be stated (1) the colon should have become damaged beyond the likelihood of recovery in spite of every medical care (2) surgery should not be delayed over long once this is established for the results of surgery are best when undertaken for those with a comparatively short history of the disease (3) as stressed by Hardy and others (1949) and by McKittrick and Moore (1949) the patient should be led to surgery by personal knowledge of its benefits which he can acquire only by contact with those who have been submitted to it and are leading the ileostomy life

The object of surgery is to remove the whole of the diseased colon and rectum and the operative plan should be devised to this end, and the patient fully informed This entails a permanent ileostomy Attempts have been made to overcome the disadvantage of an ileostomy by anastomosing the ileum to the anus, but the frequency of stool the inconvenience of wearing protective pads on the perineum and the liability to excoriation of the perineum outweigh any apparent advantages of the method Partial colectomy followed by ileo sigmoidostomy or ileo rectostomy is suitable only when the rectum is unaffected by the disease

In the past a permanent ileostomy and colectomy has entailed a multi staged operation (1) preliminary ileostomy (2) right

hemi colectomy (3) left hemi colectomy and finally (4) recto sigmoidectomy There were two reasons for this plan The first was to improve the patient s condition by ileostomy so that he would be able better to withstand operation on the diseased colon One great disadvantage of this procedure is that the patient often gets so inordinately fat after ileostomy that subsequent colectomy is made much more difficult The second was to reperitonealize raw areas Though so desirable in theory experience especially that of Dunlop (1949) and of Coates (1949) has shown that reperitonealization is unnecessary and that the time spent on this tedious manœuvre is better spent on extending the limits of the colon resection

Although ileostomy total colectomy and excision of the rectum have been successfully accomplished in one session this procedure for most cases is carrying the principle of avoiding multiple operations too far and the more expedient method of approach is to perform the operation in two stages the first being ileostomy and total or subtotal colectomy and the second after an interval of some months excision of the rectum or recto sigmoid It must be admitted however that for some of the more advanced cases discretion must be exercised and the first operation limited to ileostomy

Colectomy—Total and Subtotal

The ideal procedure is to remove the whole colon and to close the cut end of the rectum covering the stump of the latter with peritoneum at the level of the peritoneal reflexion after division of the superior hæmorrhoidal vessels This manœuvre makes it more easily possible to excise the rectum subsequently through the perineum instead of performing an abdomino perineal section as Brooke (1952) has pointed out

This step however considerably increases the length of time of operation for many patients are ill conditioned to sustain easily the additional strain that it imposes A speedier and entirely safe alternative is to divide the colon somewhere in the recto sigmoid region and to bring the divided distal end through a small stab incision in the left iliac fossa A tube may be placed in the open end of the protruding portion if thought desirable but this is not essential and it is quite safe to sew over the open end of the bowel and leave it anchored in position by tying the sutures over a length of rubber tubing lying on the surface of the abdomen

The Technique and Complications of Ileostomy

The success of surgical treatment stands or falls upon the efficiency of the ileostomy If the ileostomy behaves well it is surprising how

little it handicaps the intelligent patient who has mastered the use of the Koenig-Rutzen type of bag (Fig. 52). If the ileostomy functions poorly, however, it may well prove an intolerable burden. Complications such as recurrent obstruction, stenosis, prolapse, fistula formation, persistent excoriation of the surrounding skin, and progressive ileal distension may each or all conspire to rob the operation of all virtue and to deny the patient the reward of his submission to surgery.

It thus behoves the surgeon to study deeply the technique of ileostomy and to use all his arts to ensure, in so far as he is able, a successful outcome.

The ileostomy should lie at or about the junction of the middle and inner thirds of the right anterior spino-umbilical line. Under

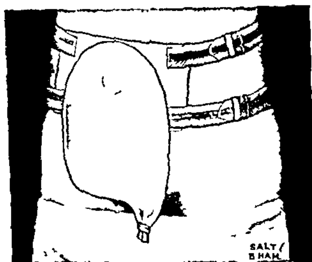


Fig. 52. Salt modification of the Koenig-Rutzen ileostomy set.

no circumstances should the opening be placed in the line of a main incision, for if weight is gained after operation, which is to be expected, the ileostomy will come to lie in a deep valley. Moreover the scar tissue above and below may contract and interfere with the mobility and calibre of the intestine. It is best to excise a disc of skin and subcutaneous tissue the size of a florin and bring the ileum through this opening, making no attempt to repair this discoid incision. If colectomy is to be performed at the same time, it is wise to excise this area of skin as the first step of the operation, for it is much easier to choose the proper site for the ileostomy before the abdomen is opened. The anterior and posterior rectus sheaths are incised for some $1\frac{3}{4}$ in. and are not repaired nor anchored to the ileal mesentery, and the rectus muscle is split in the direction of its fibres over the same extent. After the proximal end of the ileum has been brought through this incision, and grasped in a

suitable clamp the cut mesentery is sutured by interrupted stitches to the under surface of the peritoneum along an oblique line so that the ileum is not rotated, taking great care not to injure the mesenteric blood vessels About 2 in of ileum is allowed to project A large rubber catheter is prepared for use by tying a layer of 6 in wide sterile gauze around it some 4 in from its proximal end and by four or five silk ligatures placed an inch or so apart The clamp is removed and the catheter passed well into the ileum the open mouth of which is now tied around the gauze clothed area of the catheter Saline solution is run into the tube to ensure that it is patent It may be possible to retain the catheter *in situ* for seven to eight days i e until the main abdominal incision is well healed After this time it is best to anticipate spontaneous discharge of the tube by removing it and affixing an ileostomy bag which has been previously selected

The projecting ileum should be wrapped in gauze soaked in paraffin and a suitable dressing built up over the area

Though aluminium paste is widely recommended as a protective dressing for the skin around the ileostomy of recent years the author has discarded its use as an immediate post operation application for fear that it may irritate the tender thin walled ileum and thereby predispose to fistula formation

Two methods of obtaining an immediate covering for the exposed length of ileum are in vogue In one a split skin graft is applied and in the other the ileum is clothed by fashioning a rectangular flap of skin from the abdominal wall (spout ileostomy) the resulting bare area being skin grafted Though either of these methods may, if entirely successful be an improvement upon an ordinary ileostomy they have serious limitations The split skin graft is liable to lead to contraction with shortening of the ileum and an added risk of stenosis and the skin flap may fail lamentably if there is any sloughing of the edges of the flap abetted by soiling of the healing scar by ileal contents Monroe and Olwin (1949) overcome this danger of soiling by introducing by mouth a Harris tube which passes into the ileum and not opening the ileostomy for seven days The retention of an indwelling tube for so long a period is itself not without danger however and cannot be recommended as a routine procedure Finally Brooke (1952) has recently explored the possibilities of eversion of the ileum with primary suture of the everted edge to the skin No tube is inserted

CANCER OF THE LEFT COLON

TECHNICAL ease has matched perfectly the requirements for extirpation of cancer of the cæcum and right colon e extent

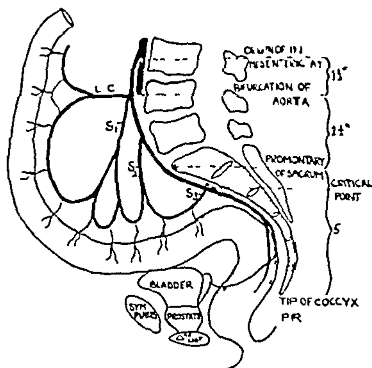


Fig 53 (a) Diagram representing the commonest arrangement of the inferior mesenteric artery and its branches in 75 necropsy room bodies Special care has been taken to relate the arterial tree and bowel accurately to the bony pelvis and lumbar spine

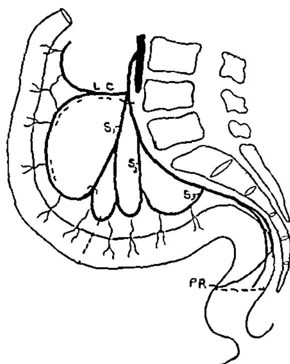


Fig 53 (b) Diagram showing method of preparation of sigmoid stump in which the first artery (S_1) is sacrificed and reliance is placed on the descending branch of the left colic artery (L C) This is the method preferred where possible

[By courtesy Mr J C Goligher and the Editor British Journal of Surgery

of the operation for cancer of the left colon has hitherto been restricted to the removal of a small segment of the bowel with a wedge of its attendant mesentery for fear of interfering with the blood supply of the lower end The names of Hartmann and Sudek will long be remembered in this context

Recent observations on the vascular supply of the left colon have enabled us to revise our traditional beliefs Goligher (1949) has shown that it is possible in practically every case to preserve a sufficiently long stump of sigmoid colon with an adequate blood supply if a ligature is placed on the inferior mesenteric artery immediately distal to the first sigmoid branch (Figs 53 (a) and (b))

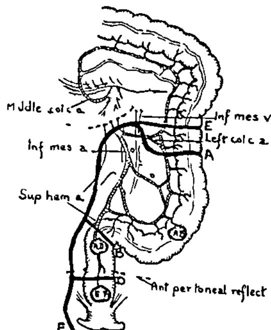


Fig 54 Segments of bowel to be removed for carcinoma of sigmoid colon A–B lower sigmoid A–D and rectum E–F with ligation of the inferior mesenteric artery at its origin above the left colic artery The levels of resection at E and A may range between distal transverse and sigmoid colon depending on the degree of mobilization of the transverse colon and splenic flexure the site of the tumour and the blood supply of the bowel

[By courtesy of Drs R. S Grinnell and R B Hiatt and the Ed for Surgery Gynæcology and Obstetrics

Provided its marginal artery is not interfered with this portion of colon is nourished adequately by the first sigmoid artery alone or in combination with the intersigmoid marginal artery or by the descending branch of the left colic artery sufficiently to enable an end to end anastomosis to be made with the rectum

Grinnell and Hiatt (1952) and Toupet (1951) find that the splenic flexure can be nourished by the middle colic artery, even if the inferior mesenteric artery is tied at its origin sufficiently for an end to end anastomosis to be made between the descending colon and the rectum Furthermore it has been shown that the blood supply of the rectum from sources other than the superior hæmorrhoidal artery is more liberal than had been supposed ufficient

to ensure survival of at least that portion of the rectum situated below the sacral promontary Thus a more radical operation which more closely fulfils the requirements for extirpation of cancer of the left colon may be envisaged, in which the inferior mesenteric artery is defined at its origin from the aorta and removed with its associated lymphatic glands The value of this extended operation has been well demonstrated by Grinnell and Hiatt (Fig 54) They carried out 41 resections for carcinoma with ligation of the inferior mesenteric artery Sixteen were for cancer of the rectum or recto sigmoid for which an abdomino perineal operation was performed In 18 tumours of the left colon were removed and continuity restored by direct anastomosis and there were seven abdomino anal pull through operations In 37 specimens dissected after operation there were 7 instances of high lymphatic metastases which could not have been removed if high arterial ligation had not been done There were three post operative deaths, only one of these being due to bowel necrosis and following one of the pull through operations

The advantage gained by this very radical operation particularly when applied to the treatment of rectal growths must be balanced against the increased risk of so extensive a procedure Until further knowledge and experience is gained it should not be adopted as a routine The great value of the work that has been done up to date lies in the knowledge that if at operation for cancer of the left colon in particular the surgeon finds reason to suspect the presence of infected glands high in the mesentery he is at liberty to attempt their removal ligating the inferior mesenteric artery either near its origin or after the first sigmoid or second sigmoid arteries have been given off according to the needs of the individual case The growth bearing area of the colon will then need to be removed to include the recto sigmoid junction if continuity is to be re established In order to bring down the proximal end of the left colon the splenic flexure will need to be fully mobilized This can best be accomplished first by mobilizing the descending colon and then by detaching the distal half or more of the transverse from the great omentum Traction on the two mobilized limbs of the splenic flexure will now facilitate its detachment from the abdominal wall

OBSTRUCTION DUE TO CANCER

The treatment of complete obstruction due to carcinoma of the colon should be restricted to relief of the obstruction and only where the obstruction is incomplete should any thought be given to immediate resection of the growth

For obstruction of the left and transverse colon the operation of blind cæcostomy has lost favour, largely because the profound relaxation which can now be obtained by curare without detriment to the patient has lessened the risk of laparotomy Laparotomy too has the great advantage of enabling the surgeon to determine the exact site and nature of the obstruction, and to assess its operability "Blind" cæcostomy should therefore be used only for patients *in extremis* in whom there is great cæcal distension

Opinions vary as to the value of the Miller Abott tube in the preparation of a patient with colon obstruction due to cancer for operation As Smith (1948) points out the tube is of little value if the ileo cæcal valve is functioning and a closed colon obstruction is present Furthermore if the stage of vomiting is reached the prospects of a successful passage of the tube is too remote to justify the discomfort to the patient and the delay in operation which an

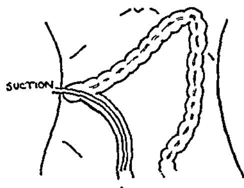


Fig 55 Ileal suction drainage following excision of partially obstructed cancer of the right colon

(By courtesy Mr E C Muir and the Editor Proc Roy Soc Med)

attempt at its passage would mean Its use would appear therefore to be restricted to the early case and for the more advanced gastric suction *via* a Ryle s tube coupled with the administration of intra venous fluids should be employed and operation not delayed for more than a few hours

If the cancer is in the left colon and the portents are in favour of the possibilities of future radical removal a simple 'glass rod colostomy of the transverse colon should be performed The site of election for this is near the hepatic flexure for this will leave the left side of the abdomen free for the radical operation to come The Paul Mikulicz operation is far less in favour than was formerly the case but still may have a place in the treatment of the condition in the aged subject

For obstructive cancer at the cæcum or in the ascending colon the operation of choice is ileo transverse colostomy the anastomoses being situated well clear of the proposed area of fut ction if

the growth appears to be re ectable In those patients in whom obstruction is only partial and who are adjudged capable of withstanding the operation immediate excision may be contemplated with an ileostomy through the unsutured end of the transverse colon as suggested by Muir (1947) (Fig 55) After excision of the growth, the distal end of the transverse colon is retained in a clamp, and a side to side ileo colostomy performed after closure of the ileal orifice The clamp on the colon is then oversewn, and the opening closed except for ½ cm at the corner farthest from the anastomosis A soft rubber tube the size of a 12 or 13 catheter, some 16 inches in length with lateral holes in it, is now inserted through the gap in the colon It is passed through the anastomosis into the ileum The tube is stitched to the colon and the bowel inverted around it with a number of circular sutures The free end of the tube is brought through a stab wound about 2 inches below the right costal margin and outside the rectus sheath, the colon around it being sutured to the peritoneal edge of the stab wound

HIRSCHSPRUNG'S DISEASE

A new approach to the problem of Hirschsprung s disease has resulted from the work of Swenson and Bill (1948) and Bodian, Stephens and Ward (1949)

These workers have defined a type of Hirschsprung s disease in which the development of a megacolon appears to be due to a congenital absence or aplasia of the nervous tissue (Auerbach's plexus) concerned in the neuro muscular control at the recto sigmoid junction thus distinguishing this type of megacolon from the acquired or functional megacolon which develops during infancy and is not present at birth

To this type the term aganglionic megacolon may be applied, and it can be distinguished from the acquired type by the onset of symptoms from birth and by radiological studies which demonstrate the presence of a narrowing of the bowel at the level of the recto sigmoid junction with dilatation of bowel above, but with the rectum unaffected (Figs 56 and 57) Cases of megacolon where no such abrupt transition can be demonstrated should not be included in this category, and are unsuitable for surgical treatment Bodian (1949) and others found that 39 of 73 cases of idiopathic megacolon conformed to the aganglionic type A narrow distal segment was demonstrated in 34 of these by radiology and in 5 at autopsy Microscopic examination showed a complete absence or diminution in number of autonomic ganglion cells of Auerbach s

plexus in the wall of the rectum and in the bowel for a variable distance above the narrowing It must be added here that despite the attractiveness of this simple explanation for the cause of megacolon doubt has been thrown upon its validity notably by State (1952) who points out that ganglion cells are not always absent from the rectum below the narrowing and are not always present above the dilated colon

The treatment for the condition is recto sigmoidectomy preferably performed in one stage If there is gross distension however



FIG 56 P A view of barium enema to show the distal narrow segment and the dilatation proximal to it



FIG 57 Oblique view to show the distal narrow segment and the proximal funnel shaped dilatation characteristic of Hirschsprung s disease

[*Figs 56 and 57 by courtesy of Dr Martin Ixl an*

which cannot be relieved by a tube passed through the narrowing and colon lavage a preliminary colostomy is performed Swenson (1951) recommends a pull through operation after resection of the recto sigmoid from a point 12 cm above the narrowing Dissection is made close to the rectum so that impotence and impaired bladder function can be avoided Bodian (1949) and his colleagues however prefer to do the operation in stages In stage one the colon is defunctioned by a right sided spur colostomy Thorough preparation of the distal segment is then made possible An interval of several months is preferred before the next stage is attempted so that the child may improve in health and th dema or

glandular enlargement in the mesosigmoid may be given time to subside. Stage two is an abdominoperineal recto-sigmoidectomy. The site of election for the proximal resection of the bowel is about half way along the cone shaped funnel situated above the narrowing. The rectum is dissected distally as far as the levator ani muscle and the narrow segment of bowel is then intussuscepted out of the pelvis through the anus. The prolapsed portion is excised leaving about 1½ inches of anal canal to which the cone shaped proximal colon is anastomosed. The third stage consists of crushing of the colostomy spur with later (stage four) closure of the colostomy.

State (1952) prefers to perform an extensive left hemicolectomy from the proximal limit of the dilatation, which is usually near the hepatic flexure end of the transverse colon, followed by intra-abdominal anastomosis of the residual transverse colon to the rectal stump 6-10 cm above the anus.

Results

Swenson (1951) claims a cure in 28 of 31 cases, Bodian and others (1951) 32 satisfactory results of 37 patients operated upon, and State (1952) much improvement in all but one of 15 cases.

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plexus in the wall of the rectum and in the bowel for a variable distance above the narrowing It must be added here that despite the attractiveness of this simple explanation for the cause of megacolon doubt has been thrown upon its validity notably by State (1952) who points out that ganglion cells are not always absent from the rectum below the narrowing and are not always present above the dilated colon

The treatment for the condition is recto sigmoidectomy preferably performed in one stage If there is gross distension, however



FIG 56 P A view of barium enema to show the distal narrow segment and the dilatation proximal to it



FIG 57 Oblique view to show the distal narrow segment and the proximal funnel shaped dilatation characteristic of Hirschsprung s disease

[*Figs 56 and by courtesy of Dr Martin Bodian*

which cannot be relieved by a tube passed through the narrowing and colon lavage a preliminary colostomy is performed Swenson (1951) recommends a pull through operation after resection of the recto sigmoid from a point 12 cm above the narrowing Dissection is made close to the rectum so that impotence and impaired bladder function can be avoided Bodian (1949) and his colleagues however prefer to do the operation in stages In stage one the colon is defunctioned by a right sided spur colostomy Thorough preparation of the distal segment is then made possible An interval of several months is preferred before the next stage is attempted so that the child may improve in health and that any œdema or

CHAPTER XV

THE RECTUM AND ANUS

E G MUIR

CONGENITAL DEFORMITIES OF THE RECTUM AND ANUS

IMPERFORATE ANUS

ANORECTAL anomalies are uncommon and are said to be present in 1 5 000 births For this reason it is unusual for any one surgeon to acquire great experience in this condition, yet it is an emergency calling for rapid recognition and treatment In the past operative treatment has carried a heavy mortality, and it might be expected that the recent advances in the antibiotics, resuscitation and anaesthesia would lead to improvement Recent accounts confirm this and show a more radical approach to the treatment of this deformity in the newborn

The condition is almost equal in the sexes and other congenital anomalies are frequently present (72 per cent Moore and Lawrence, 1952) and may themselves account for the infant's death It is usual to classify these cases in four groups (Ladd and Gross, 1934) In the first there is patency but an anorectal stricture In the second the rectum is separated only from the anus by the intact proctodæal membrane In the third the rectum ends blindly, or by a fistulous track a varying distance above the perineum and in the fourth a normal anus and lower rectum are separated by a varying distance from the proximal part of the bowel

I *An anorectal stricture only* accounts for 5 to 10 per cent of these cases and may occasionally pass unrecognized for some months if the external appearance of the anus is normal Browne (1951) draws attention to the " microscopic " anus, where only a speck of meconium may indicate the orifice, and to the occasional occurrence of a thick band of tissue (the perineal raphe) passing across the anal site with a minute orifice on one side

II The rectum is separated from the anus by an intact thin bulging proctodæal membrane This also is unusual (5 to 10 per cent)

Neither of these conditions present great difficulties in their initial treatment A stricture requires dilatation and occasionally incision an intact membrane must be excised It is essential that regular

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Hirschsprung's Disease

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BODIAN M, CARTER C O and WARD B C H 1951 *Lancet* i 30?
LEE C M and BLBB K C 1951 *Surgery* 30 1020
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daily dilatation should be continued until the anal canal is not only normal in size but shows no tendency to contract The mortality is low and the results of treatment are usually good

Between the second and third types of imperforate anus there are many gradations for if the lower end of the rectum fails to reach the proctodæal pit it may open by a track of varying size in a descending arc from the bladder, prostatic urethra, upper vagina, lower vagina bulbar urethra or end as a perineal sinus or an other

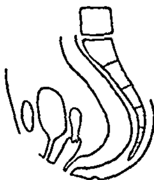


Fig 64 Ectopic anterior anus in the female shotgun perineum

wise normal anal orifice in a forward ectopic position (Figs 58–64) A fistula is present in 70 to 80 per cent of this type

Ectopic Perineal Anus

In the female the anal orifice may open beside the vaginal orifice without intervening skin the ' shotgun ' perineum described by Browne (1951) in the male it may be found just posterior to the scrotum If the orifice is functioning normally it should be left where it is at least until a later date If stenosed it may be treated by dilatation or simple backward incision and dilatation The same treatment is recommended where the anal orifice opens just within the lower vagina, or the more elaborate procedure of transplanting the anal orifice to its correct site Whatever treatment is to be adopted it is essential that any stenosis should be corrected rapidly

III This type of malformation accounts for nearly 80 per cent of recorded cases The anus is imperforate the site being marked by a dimple converging skin folds some pigmentation or without trace The rectum ends a varying distance above the perineum and in 70 to 80 per cent in a fistula with the bladder, prostatic urethra vagina or perineum Involvement of the bladder is rare the prostatic urethra and vagina common

Fistulæ in the perineum or the posterior vaginal wall will be visible through the passage of meconium and air In the male the presence

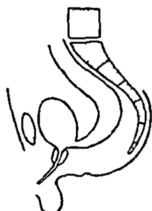


Fig 58

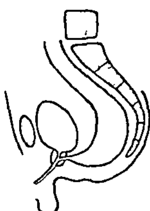


Fig 59

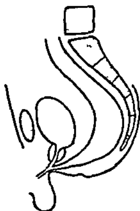


Fig 60

Figs 58–60 Diagrams illustrating varieties of congenital recto urinary fistulæ in the male Figure 59 represents the most common type of recto urinary fistula

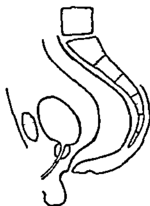


Fig 61 Ectopic anterior anus in the male Instead of a normal anus in a forward position the rectum may terminate in a sinus opening in the same site

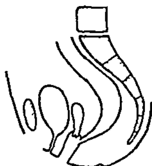


Fig 62

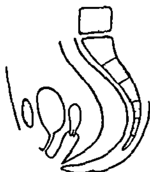


Fig 63

Figs 62 and 63 High and low congenital recto vaginal fistulæ in the female

urinary fistula is present it is retained for ten days This operation would seem a severe proceeding but its mortality in some hands has been surprisingly small Santulli (1952) reports 21 such operations in males without mortality in 7 newborns without colostomy and Moore and Lawrence (1952) report 11 cases without death Gross (1952), attributing this form of repair to Dr Jonathan Rhodes stated that of 76 cases there were only 4 deaths He considered that probably 70 per cent of these cases developed a good functional sphincteric action, a result which is considerably higher than might be expected

3 In the female infant with a rectovaginal fistula, Santulli (1952) advises the removal of the anal orifice from the posterior vaginal wall and its implantation into the anal region by a perineal dissection Out of 25 cases he obtained excellent functional results in 8 and good results in 5 If the fistula is of sufficient size or can be dilated to sufficient size there is no urgency but some form of operative treatment will be immediately necessary if it is not For low rectovaginal fistulæ Browne (1951) advises posterior incision and dilatation

4 In the female infant without a vaginal fistula the treatment will be a perineal approach if the rectum is believed to be low, or transverse colostomy or abdomino perineal repair if it is high

IV In this rare condition the anus and lower rectum are developed but there is a failure of fusion with the rest of the bowel The condition tends to be recognized late, and Moore and Lawrence (1952) report a 100 per cent mortality

BENIGN EPITHELIAL TUMOURS AND MALIGNANT RECTAL POLYPS

These two conditions are closely related for it is recognized that any epithelial tumour of the large bowel is a potential site for carcinoma Congenital familial polyposis is here excluded and the tumours under consideration may be small and slender stalked, sessile or villous They have this in common either they are clinically innocent, or, if malignancy is suspected the tumour is of such small size that local removal is considered

Rectal polyps particularly the adenomata, are undoubtedly common De Muth Cherney and Fitts (1952) report an 8 per cent incidence in a group of fifty routine sigmoidoscopies performed on patients over forty eight years of age Both polypi and carcinoma of the large bowel are most common in the rectum and the presence of scattered small adenomata around a rectal growth is a common place

of meconium in the urine is naturally evidence of a recto urinary fistula It is of great importance to determine the distance of the rectum from the perineum Bulging on crying suggests a low rectal pouch, and an X ray taken after the baby has been held inverted for some minutes may show air in the rectum and its proximity to a marker in the anal region Unless a fistulous track is present, and of sufficient size, signs of intestinal obstruction will soon be evident

1 In male infants without urinary fistulæ and where the rectum is believed to be only a short distance from the skin, perineal exploration should be performed by an incision backwards from the anal region to the coccyx The rectum is identified mobilized opened and sutured carefully to the skin with fine silk sutures to construct a new anus Santulli (1952) advises the use of a urethral catheter during the operation to aid dissection and the suture of the divided external sphincter muscle behind the anus If the rectum is superficial and has been easily found the chance of a good functional result is high, and especially when a narrow superficial sinus passes forward from the anal region to open at the base of the scrotum Browne (1951) explains this type as the abnormal fusion of the external genital folds covering a normally developed anus which only requires exposure Unfortunately this type is not common

While there is a good chance of success if the rectum is found to be superficial it is an unfortunate error if it proves to be deep A colostomy, which should be performed in the transverse colon is urgently required and the scarring in the perineum may hinder later attempts at reconstruction For this reason deep dissection in the perineum is unjustified at this stage

2 In male infants with a urinary fistula or with a high rectal pouch, a transverse colostomy a later suprapubic cystostomy and in later years subsequent attempts at reconstruction through the perineum has been the usual procedure Recently a number of surgeons have advocated either an immediate, or if colostomy has already been employed at least an early abdomino perineal operation Through an abdominal incision the sigmoid colon and rectum are mobilized from the sacrum without damaging the blood supply, separated from the vesicles and prostate and the fistulous opening identified divided and oversewn A small incision is then made in the anal region and a clamp introduced into the abdomen through the correct site in the levatores ani muscles The lower end of the rectum is grasped pulled through into the perineum and sutured to the skin A urethral catheter facilitates d[illegible] and if a

RADICAL RESTORATIVE RESECTION IN THE TREATMENT OF RECTAL AND RECTO-SIGMOID CANCER

Many surgeons now feel that this operation has an important part to play in the treatment of rectal and recto sigmoid cancer to some its use is never justified It is a temptation to surgeon and patient alike to accept a course which will avoid a permanent colostomy and before embarking on an operation of this nature the surgeon must weigh carefully its advantages and disadvantages

While there are a number of different methods by which this operation may be performed that in common use is an anterior resection In this a varying amount of the rectum and sigmoid colon are resected through the abdomen the anastomosis between the proximal sigmoid and the rectal stump being performed in the depth of the pelvis The following are the essentials for an effective radical restorative resection (Morgan and Lloyd Davies 1950 Muir 1948 1952)

1 The inferior mesenteric artery must be ligated at a point not lower than would be used for a combined excision As a rule this lies immediately below the first sigmoid artery or if there is a common origin to this vessel and the left colic immediately below the latter Recently it has been suggested that the inferior mesenteric artery should be ligated at its aortic origin in order to remove still more of its associated lymphatic chain (Ault, Gastro and Smith 1952 Grinnell and Hiatt 1952) These writers hold that the marginal arteries are quite sufficient to nourish that part of the sigmoid to be used in the subsequent anastomosis

2 After mobilization it must be possible to divide the bowel at least 2½ in below the lowest limit of the growth The work of Dukes (1944) and others has shown that it is very uncommon for a growth to spread more than 5 cm downwards in the superior hæmorrhoidal and pararectal lymphatics and that such spread is usually confined to advanced or highly malignant growths

3 A sufficient rectal stump must be left to ensure proper continence While some form of continence is sometimes obtained after the removal of almost all the rectal mucosa, it is generally accepted that a rectal stump of some 5 to 6 cm from the anal margin is desirable (Gaston 1952 Goligher, 1951) This stump should be free from adenomata or suitable treatment should have been given

4 Growths below the peritoneal reflection of the rectum drain not only upwards but also laterally to the lymph glands on the side wall of the pelvis That part of the bowel is not enclosed in a

Polypi should always be removed and in such fashion as will permit a careful pathological examination, this is usually performed by the diathermy snare The variations in instruments current and procedure have been recently summarized by Frankfeldt (1952) the early stages of malignancy by Fisher and Turnbull (1952) and Lockhart Mummery and Dukes (1952)

The progressive changes in malignancy have been described as 'carcinoma *in situ*' focal carcinoma and "invasive carcinoma" The first can be classified as a suspicious lesion the second as a definite carcinoma but confined to the mucosa and the third shows invasion of the submucosa to a varying degree From a series of 47 cases classified in this manner and graded in malignancy as high low or average Lockhart Mummery and Dukes have drawn certain conclusions

As far as is practical the whole of a rectal polyp should be removed for pathological examination for this not only permits classification and grading but enables the pathologist to assess the completeness of removal Assuming the removal to have been complete with a free margin local removal alone can be judged sufficient if the carcinoma is '*in situ*' or only focal' If it is invasive the decision should be influenced by the grading For a tumour of low malignancy local removal would seem to be sufficient for high malignancy radical surgery is necessary and for average malignancy a choice of radical surgery or continued and careful supervision While each case calls for individual consideration evidence suggesting incomplete removal of a malignant polyp generally indicates radical surgery whatever the grading of the growth

The treatment of the large villous tumour of the rectum presents a most difficult problem If biopsy shows malignancy the issue is clear but a negative biopsy does not exclude it Further the actual extent of these soft tumours is often impossible to define with the finger and sometimes with the naked eye For these reasons and because of the frequency of recurrence after local excision Gabriel (1952) advises a combined excision While this provides a complete solution to the problem in the absence of proved malignant disease it is not one which every surgeon would accept Alternatives are an anterior resection a pull through or an abdomino anal resection the two latter permitting an even lower excision of rectal mucosa Unfortunately some villous tumours may extend down to the anal canal and in such cases the surgeon has only a choice of radical excision or an accepted incomplete removal

The Results of Radical Restorative Resection

The mortality rate of these operations would appear to be less than that of a combined excision In anterior resection it is under 5 per cent, and that is a satisfactory mortality rate for a major operation which is usually performed on patients in the seventh or eighth decade Although anterior resection is a more time con suming procedure than a combined excision, there appears to be less operative shock with the absence of a perineal operation and the post operative course is more comfortable

Survival Rate after Radical Restorative Resection

The largest series reviewed is that of Dixon (1948) who found a five year survival rate of 67 7 per cent for restorative resection compared with 44 8 per cent for combined excision It should be remembered however that it would be the high rectal growths that would be treated by restorative resection and that they have in any case a better prognosis The question which must be answered is whether a high rectal growth treated by restorative resection has as good a post operative prognosis as a similar growth treated by combined excision It is believed that the results are comparable, but they can never be quite so good and for two quite definite reasons

1 Combined excision leaves no rectal stump In a restorative resection part of the rectum remains, and this can only be regarded as part of a pre cancerous bowel and a suitable site for a further growth It is not so uncommon for a patient who has had a com bined excision to develop later another primary growth in the colon, or for a carcinoma of the colon to be followed later by a carcinoma of the rectum or for more than one primary growth to be found in the large bowel at an operation Apart from congenital familial polyposis, however, no surgeon would suggest that because a patient has had a carcinoma of the colon the whole of the large bowel should be removed, but the rectum is the most common site for large bowel cancer, and there must be a risk in failing to remove it completely when part of it has already been the site of a growth

2 The risk of recurrence in the anastomotic line Foci of growth may be left behind in the soft tissues of the pelvis after a combined excision, and this is more common with low rectal growths (Gilchrist and David, 1947) If a restorative resection were performed for a low rectal growth the same fault might occur, and the recurrence might subsequently involve the anastomotic line A number of cases have, however been recorded where recurrence took place

peritoneal envelope and has a much more intimate contact with pelvic fat, fascia levatores ani muscles, adjacent organs and their lymphatics For this reason growths in this region should be treated by widespread excision and are regarded as quite unsuitable for a restorative resection

The Choice of Case

The number of cases suitable for radical restorative resection in the hands of those surgeons who practise the operation is probably not more than 20–25 per cent of all operable cases of rectal and recto sigmoid cancer The choice of case will depend on a number of factors some of which have already been discussed

1 The growth should be at least 10 cm from the anal verge and 5 cm above the lowest level of peritoneal reflection in the pouch of Douglas The height of the growth above the cervix or seminal vesicles on rectal examination is of clinical value in estimating suitability, but a final decision can only be made at laparotomy Recto sigmoid and growths of the distal sigmoid colon are usually suitable

2 The growth should be early and not of high malignancy Both an advanced growth and a highly malignant growth are more likely to be effectively removed by a combined excision

3 In an obese subject with a small pelvis the operation may be difficult to perform If this is likely to lead to an ineffective clearance of the growth the operation should be abandoned and a combined excision performed

4 The sigmoid colon mobilized by freeing the descending colon and if necessary the splenic flexure, must reach the rectal stump without tension and with a good blood supply

Restorative Resection as a Palliative Operation

This operation is also suitable for cases of rectal cancer locally operable with hepatic metastases but it should be borne in mind that failure to remove a sufficient margin of bowel below a growth may lead to local recurrence before the patient s death

Colostomy

When obstruction is present a right transverse colostomy should be a preliminary to an anterior resection It may also be used at the time of operation if pre operative preparation appears to have been ineffective or there is doubt about the safety of the anastomosis The use of the sulphonamides and the antibiotics now makes a routine colostomy less common

Radical Resection

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at the recto sigmoid anastomosis and soft tissue recurrence could almost certainly be excluded (Lloyd Davies 1948 Muir 1948 1952 Long Mayo Dockerty and Judd 1950, Goligher Dukes and Bussey, 1951)

It is thought that the reappearance of cancer at the anastomotic line may be due either to a fresh growth developing stimulated by the process of repair in pre cancerous bowel, or to implantation of cancer cells on the raw tissues at the time of the anastomosis To lessen the danger of the latter it is advised that during the operation the lower rectum should be washed out once a clamp has been applied below the growth Cole (1952) considers that the danger of cancer cell implantation on anastomotic lines through small particles of growth set free into the lumen of the bowel during surgical manipulation is probably not uncommon Certainly if it occurs in the recto sigmoid anastomosis after restorative resection where the anastomotic line can be both felt and seen in post operative surveillance there is no reason to suppose that it does not occur after other operations on the colon

It is not yet possible to estimate the frequency with which carcinoma reappears after a radical restorative resection It may be in the region of 10 per cent and it should be remembered that whatever the cause this particular type of recurrence could not occur with a combined excision When such recurrence is treated by a combined excision the operation is a difficult one and there is an increased risk of ineffective removal

Radical restorative resection has certain advantages and as an anterior resection should be used much more frequently for growths of the sigmoid colon whose lymph field resection is frequently inadequate Its use calls for great care in the selection of patients and a knowledge of the risks which must be accepted

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DeMuth W E Cherney P J and Fitts W T 1952 *Surg Gynec Obstet* 94 195
Fisher E R and Turnbull R B 1952 *Ibid* 94 619
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Lockhart Mummery H E and Dukes C E 1952 *Lancet* [illegible] 751

in jejunal diverticula, there may be some evidence of compensatory hypertrophy of the muscularis mucosa in the wall of the pouch

The vessel whose channel through the muscular coat determined the site of herniation can usually be demonstrated In the small intestine the blood vessels pass through the muscle coat almost immediately they leave the mesentery, hence the diverticula are closely related to the latter, in the colon the blood vessels, after leaving the mesentery, pass under the serous coat to the edge of the longitudinal muscle band before piercing the circular coat to reach the submucosa Hence diverticula of the colon appear in two rows on either side of the mesentery and at some distance from it As the blood vessel passes under the longitudinal muscle of the colon a small branch is given off to the corresponding tænia epiploica, thus in obese subjects the pouches are often obscured by fat

Diverticula of the duodenum and jejunum may become very large—of golf ball size and over—but colonic diverticula rarely exceed the size of a grape

Clinical Aspect

The underlying cause for clinical symptoms due to diverticula is retention of intestinal contents, to which they are predisposed by their deficient musculature and their bottle neck communication with the parent intestine The nature of both symptoms and complications will thus depend largely upon the nature of the contents and the anatomy of the area of bowel from which the diverticula arise

The Duodenum

Hernial diverticula of the duodenum are to be found in about 2 per cent of all radiological examinations of the gastro intestinal tract, and about 80 per cent of these appear at the site of entry of the common bile duct into the duodenum, and are hence called *perivaterian* Except when situated at the duodeno jejunal flexure, duodenal diverticula other than perivaterian very rarely give rise to symptoms

The first part of the duodenum is never the seat of hernial diverticula and pouching in this situation is the result of chronic duodenal ulceration The affected part of the duodenum is shortened by contraction of scar tissue due to ulceration, and the unaffected unscarred portion of the duodenum balloons outwards Though evidence of attenuation of the muscular wall may be found at the fundus of such pouches when they are large and of long standing in the early stages their wall is normal They never give rise to

CHAPTER XVI

DIVERTICULOSIS AND DIVERTICULITIS OF THE INTESTINE

HAROLD C EDWARDS

Introductory

DIVERTICULA of the small and large intestine are acquired by a process of herniation of the mucosa through the muscle coat of the bowel and are an affection of middle age and later The mechanism as with herniation through the abdominal parietes is exceedingly complex and little understood It is generally agreed that two basic factors are concerned—pressure within the cavity of the bowel, which forces the mucosa against the muscularis and an outlet or locus minoris resistantiæ such as that provided by the gap in the muscle coat occasioned by the passage of blood vessels or in the case of the duodenum by the common bile duct The unknown factor lies in the behaviour of the plain muscle itself upon which layer the integrity of the bowel wall depends It has been demonstrated that atonicity or atrophy of the muscle is not a constant or even a common causal factor Not only does the microscopic anatomy bear evidence against such a supposition but it is well known that passive pressure alone as in acute obstruction, does not produce pouching It has been suggested that local spasticity of the muscle wall is a more probable antecedent to herniation and there the matter rests All those contributory factors which arrive coincidentally with middle age and which predispose to external herniæ are doubtless concerned and the tendency to diverticulosis increases with age

Anatomy

The muscle coat of the intestine usually ends abruptly at the orifice through which the mucosa is extruded though it may be everted to accompany the hernia for a short distance The muscularis mucosæ accompanies the mucous membrane so that a few fibres may be present throughout the diverticulum, although in the fully formed diverticulum the fundus usually consists of mucous membrane covered only by the serosa Occasionally, more especially

stressed always that unless there is unequivocal evidence of delay in the diverticulum the latter should not be regarded as the cause of the symptoms (Fig 65, *a* and *b*)

Perforation of a perivaterian diverticulum is almost unknown but other complications are recorded, e g chronic pancreatitis obstructive jaundice Seldom however can *diverticula* be held



Fig 65 (*b*) The diverticulum after removal

[*By courtesy the Editor Postgraduate Medical Journal*

responsible for either, and any association between the two is likely to be coincidental

Management It is probably advisable to ignore the presence of a small duodenal diverticulum discovered by barium meal Knowledge of its existence is of no material value to the patient and there is no known treatment which can influence it in any way Operation should be considered only when the diverticulum is large and retains barium after the stomach has been empty for several hours

symptoms *per se*, and their significance lies in furnishing absolute evidence of past or present duodenal ulceration

Periaterian diverticula are usually single They nearly always arise in posterior relationship to the common bile duct and pass to the left behind the head of the pancreas being separated from the latter by a layer of areolar tissue Many of the patients are visceroptotic The diverticula do not give rise to recognizable symptoms



Fig 65 (*a*) Twenty four hours retention of barium in a duodenal diverticulum

until they have enlarged sufficiently to retain duodenal contents for a significant period The symptoms are then those of a flatulent dyspepsia, with a sense of oppression in the epigastrium after meals and borborygmi Pain is not a common symptom The mimicry of chronic cholecystitis is particularly close and acquired diaphragmatic hernia may also produce similar symptoms It must be

prevention The incidence of the complication of diverticulitis cannot easily be assessed, for the border line between it and diverticulosis is often ill defined Severe diverticulitis is, however, comparatively rare One unexplained feature is that whereas diverticulosis shows little discrimination between the sexes, diverticulitis is at least two and a half times as common in men as it is in women

The possible complications are set out in the accompanying

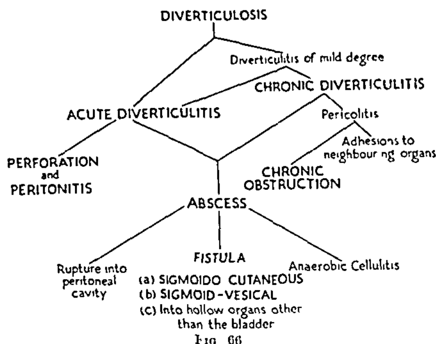


Fig 66

scheme (Fig 66) Only those in capitals demand specific attention

Management of Diverticulosis and Diverticulitis of Mild Degree

The majority of patients with diverticulosis go through life without suffering any untoward symptoms from that source It is thus probably wisest if diverticulosis is revealed "by accident" and if there are no signs that any inflammation is present, not to make the patient aware of his condition The most that should be done is to advise from a general standpoint, avoidance of constipation Regimentation in diet which is a life sentence, should be reserved for those in whom there is already some evidence of diverticulitis e g occasional pain or discomfort in the left iliac fossa, increasing irregularity of bowel action, radiological evidence

Diverticula at the Duodeno-jejunal Flexure

Diverticula here tend to increase in size quickly probably because their mouth is at the acute turn of the bowel, and they are thus placed at a great mechanical disadvantage They tend to burrow to the right underneath the peritoneum, and when of large size may cause intermittent duodenal obstruction For this reason operation for their removal should usually be undertaken

The Jejunum

Diverticula are less common in the jejunum than the duodenum, probably because of the part played in the formation of the latter by the common bile duct The condition is one of progressive diverticulosis with multiple pouches, which spreads down the bowel rarely reaching the ileum it resembles diverticulosis of the colon in this tendency to progression In old people many hundreds of pouches may be found

The symptoms caused are similar to those caused by perivaterian diverticula but may be even more pronounced especially as far as borborygmi are concerned In addition however when large—and they may grow to the size of a tangerine—they tend to cause intermittent jejunal obstruction with hypertrophy of the jejunal wall The diverticula may occasionally become acutely inflamed and may rarely perforate Spontaneous hæmorrhage has also been recorded

The attitude to the treatment of uncomplicated cases should be at least as conservative as with perivaterian diverticula particularly in view of the tendency to progressive involvement of the bowel Operation should be entertained only when radiology demonstrates prolonged retention

At operation the best policy is probably to resect the segment of jejunum which bears the largest pouches i e those which are responsible for symptoms

The Colon

Diverticulosis of the colon is an exceedingly common finding in patients of forty five and older In its characteristic form it is a progressive disorder chiefly affecting the sigmoid but as age advances spreading to involve the whole colon In extreme cases, both the vermiform appendix and the rectum may be involved

Occasionally diverticula are confined to the cæcal region (*q v*)

Though surgery is chiefly concerned with the treatment of the complications, the surgeon should be concerned also with their

exteriorization should he feel that perforation is imminent but on the whole, he will be best advised to delay interference and treat the patient by rest in bed a fluid diet, and antibiotics, of which streptomycin is probably the most effective At this stage aperients and lavage must be avoided

Perforation and Peritonitis

Perforation may be the first indication of the presence of diverticula in the bowel in the younger age group A violent seizure of acute pain is followed by evidence of spreading peritonitis, which should lead to immediate laparotomy The greatest danger is in delay Perforation is however, more commonly a complication of the established condition and may be the climax of a severe exacerbation of diverticulitis At operation a thickened and greatly inflamed colon is then found and though pus with fecal material and foul smelling gas are discovered on opening the abdomen it may be impossible to find the actual perforation In some such cases the peritonitis is doubtless due to rupture into the peritoneum of a pericolic abscess and the communication of the latter with the lumen of the bowel may have become sealed off

Occasionally perforation into the peritoneal cavity, particularly in long standing cases of diverticulitis, may cause very mild symptoms there being little inflammatory reaction by the peritoneum The explanation for this is not known

The prospect of recovery after early operation for perforation will vary with the length of history of diverticulitis which precedes the catastrophe and with the degree of pericolitis revealed at operation The prognosis after early operation in patients with no previous history or a history of short duration is excellent, for the bowel wall is still flexible and the perforation can readily be found and easily closed The closure is *reinforced by omentum and the pelvis* drained In some recovery may be complete and the patient experience no further trouble in others a sigmoido cutaneous fistula may develop (*q v*)

The real problem is in the surgical management of those cases in which there has been a long history of recurrent attacks of diverticulitis and in which at exploration the bowel is found to be immensely thickened and congested and particularly in those in whom the actual point of perforation cannot be identified In such an event the safest procedure is to exteriorize the bowel, if this is practicable An alternative is to attempt to seal off the inflamed area with pericolic fat and omentum in the old and the very ill patient the operation may need to be restricted to this procedure In others

of bowel spasm or rigidity and of fæcal retention in the pouches Treatment for such patients is based upon three factors avoidance of constipation, elimination of indigestible foods from the diet and bowel lavage

Chronic Diverticulitis with Recurrent Exacerbations

The process is a continuous one, marked by periods of exacerbation in which are presented all the signs and symptoms and constitutional disturbances attendant upon the presence of an inflammatory mass in the left iliac fossa sometimes including the passage of blood This clinical state is the usual prelude to perforation to abscess to fistula and to obstruction

It is generally held that the role of the surgeon only begins when one or other of these serious complications has developed Accumulated experience of the fate of those who come to surgery late or for whom palliative colostomy has been performed has given rise to misgivings as to whether this conservatism is always justified With the perfection of those new methods which have so greatly increased the safety of intestinal surgery it is necessary to take fresh stock of the situation Resection of the inflammatory mass during a quiescent period and when the process is yet young is an attractive and effective alternative to some palliative procedure deferred until the disease is long established and the dangers of radical operation increased by the grosser nature of the lesion and the added years of the patient

There is called for not so much a categorical formula for treatment but a change of attitude from let us await complications before surgery in o let us circumvent complications by surgery The fate of many patients who have been subjected to colostomy as the sole treatment of diverticulitis including its complications bears evidence that its use should rarely if ever be entertained except as a preliminary to a radical operation

The ideal procedure is segmental resection of the affected area and restoration of continuity by immediate end to end anastomosis with Paul s operation as an alternative possibility A temporary proximal colostomy should normally precede resection by some months

Diverticulitis during an Acute Exacerbation

It is important to envisage the probability of the presence of an abscess in the pericolic tissue during an acute exacerbation and by treatment to endeavour to prevent its spread There may be occasions when the surgeon is tempted to consider operation and

exteriorization should he feel that perforation is imminent but on the whole he will be best advised to delay interference and treat the patient by rest in bed, a fluid diet, and antibiotics, of which streptomycin is probably the most effective At this stage aperients and lavage must be avoided

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in whom there is a prospect of subsequent resection, a transverse diversional colostomy should be performed at the same time. In either event the peritoneal cavity should be drained and antibiotics given.

Abscess

Abscess formation is a very common accompaniment of recurrent diverticulitis. The abscess may be small and may not give clinical evidence of its presence, but remain buried in a thick mass of pericolic fibrous tissue. It may, however, develop quickly and form a large collection of pus under tension seeking an exit. It may burst into the peritoneal cavity, into a neighbouring hollow organ, or into the abdominal parietes on the left side. The bursting of an abscess into the peritoneal cavity usually causes acute spreading peritonitis, demanding immediate operation, the method of operative procedure being as for perforated diverticulum. The outlook for such cases is grave. Occasionally, however, evidence of rupture of an abscess may be slight and may cause little peritoneal reaction. Rupture of an abscess into neighbouring bowel may result in spontaneous relief from symptoms. Rupture into one of the female pelvic organs, and even into the ureter, has been described, but the commonest organ to be affected is the bladder, with later development of sigmoido-vesical fistula.

The appearance of an abscess underneath the abdominal parietes is self-evident and the treatment should be immediate drainage without any direct attack upon the bowel. Drainage of such an abscess usually results in relief from the acute diverticulitis, but a fistula will probably persist through the drainage wound (sigmoido-cutaneous fistula). Occasionally an abscess may develop in the parietes insidiously without any preceding history of a severe attack of diverticulitis, closely resembling a cold abscess due to tuberculous disease.

Sigmoido-cutaneous Fistula

Fistulæ on to the skin, which may sometimes be multiple, are rarely spontaneous, but usually develop after opening an acute abscess, after operation for perforation, or as a complication of radical operation upon sigmoido-vesical fistulæ. Those following drainage of an abscess tend to heal spontaneously and the question of operation should, therefore, in any case, be deferred for several months. A decision will finally be needed as to whether the fistula should be allowed to remain or an attempt at cure be made. The latter must be of a radical nature, with excision of the affected

bowel, for no compromise is permissible between doing nothing and the radical operation

The decision to operate will rest mainly upon the age and general condition of the patient The fistula may cause little inconvenience and may be well tolerated by the patient, especially if old Its presence acts, in fact, as an insurance of some degree against the development of further inflammatory masses In the younger age group and in those who find the presence of a fistula embarrassing and irksome radical operation should usually be attempted At the present day the procedure is a safe one and the only serious risk is a recurrence of the fistula as a result of leakage from the suture line Though it is possible sometimes to do the operation in one stage it is usually expedient to precede the excision by a transverse colostomy allowing some two to three months between the two operations

Sigmoido-vesical Fistula

Diverticulitis is the commonest cause of sigmoido vesical fistula Usually it is a complication of recurrent diverticulitis which has been a cause of ill health for some years, though it sometimes occurs in the younger age group following a short history of diverticulitis In 15 cases the average duration of symptoms of diverticulitis preceding the development of a fistula in the bladder was three years and nine months

The history varies considerably, but usually the formation of a fistula is preceded by an acute attack of diverticulitis with pyrexia, the appearance of a tender mass low down in the left iliac fossa and frequency of micturition The tender mass is due to an abscess which eventually ruptures into the bladder with immediate relief of the acute abdominal symptoms, but exacerbation of urinary symptoms There is severe vesical pain with intense frequency, and the urine is heavily laden with fæcal smelling pus There may also be hæmaturia Gas followed by fæces, may not appear for some days, though a week or more may pass In one case pneumaturia was not established as a regular feature until after many months The interval between the rupture of the abscess and the presence of fæces will depend upon the length of time it has taken to establish a fistulous track

The acute bladder symptoms tend to subside quite quickly and may eventually disappear After some weeks the bladder mucosa except at the site of the fistula will return to a normal cystoscopic appearance After the initial outpouring of fæces the fistula is liable to close sufficiently to prevent any further escape of semi solid

material except as an occasional incident and the main symptom will therefore be the passage of gas per urethram

Ascending infection of the kidney is rare and this should be taken into account when considering treatment Once a fistula has declared itself it is wise to defer any question of operative treatment for some months, in order to allow the pericolic inflammation to subside and to allow the bladder to establish immunity Furthermore the fistula may rarely heal spontaneously

The criteria for operation are similar to those governing sigmoidocutaneous fistulæ with perhaps a little more emphasis upon conservatism There should be no compromise between non interference and radical cure Colostomy alone is an infliction and not a cure and should be rigidly avoided, for it adds to the patient s discomfort without necessarily affecting the fistula

Older people and especially in those whose fistulæ developed after a long history of recurrent diverticulitis are best advised against radical operation though selection of cases for operation is a matter of clinical judgment and cannot be the subject of any *ex Cathedra* statements Radical cure should certainly be entertained in the younger age group of patients and especially in those in whom there has been no great length of history of diverticulitis before the fistula developed The principle of a preliminary transverse colostomy preceding the radical operation by two to three months should usually be followed Temporary supra pubic drainage of the bladder after repair of the fistula and resection of the involved bowel is desirable

Obstruction

The mass of fibrosis which develops around the inflamed sigmoid may be responsible for producing acute small intestine obstruction as a result of adhesions This is a rare consequence, however and the more likely result is a narrowing of the sigmoid from contraction of the scar tissue The state of chronic obstruction which results may closely simulate carcinoma of the bowel Diagnosis between the two is in fact not always possible though the history and the radiological appearance particularly if a double contrast enema is used will usually enable the differential diagnosis to be made It is necessary to emphasize that the presence of diverticula in the colon as revealed by the radiograph does not preclude the possibility of new growth for, although there is no evidence of direct causal association between diverticulosis and cancer both are common In a series of 162 patients with diverticulosis, nine had radiological evidence of cancer of the bowel In other words the

diverticulosis patient is neither more nor less liable to cancer of the bowel than is the normal subject.

It goes without saying that chronic obstruction due to diverticulitis will demand surgical relief. In older people who are poor operative risks a short circuit operation around the area of the obstruction is an excellent alternative to any attempt at resection. Permanent colostomy should be avoided.

Diverticulosis and Diverticulitis of the Cæcum

Diverticulitis of the cæcum occupies a somewhat special place, for it differs from diverticulitis of the sigmoid colon in three particulars —

1. The age incidence is lower.
2. The pouches are often solitary.
3. The pouches are peculiarly liable to cause acute symptoms.

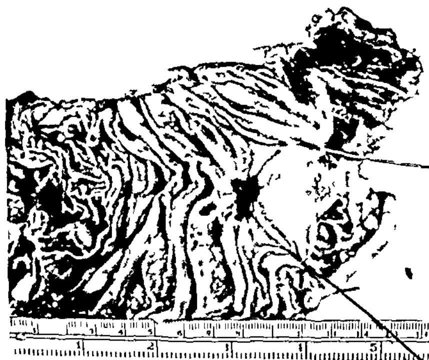


FIG. 67. Solitary diverticulum of the cæcum. Operation specimen from a man of 42.

Acute diverticulitis of the cæcum, which closely resembles acute appendicitis in its clinical features, may in fact be the first indication of the presence of a pouch. Rarely, chronic inflammation of a diverticulum causes a mass in the right iliac fossa which is liable

to be mistaken for cancer and the true nature of which only comes to light after excision (Fig 67)

The management of a case of acute diverticulitis revealed at operation undertaken on a diagnosis of acute appendicitis will vary according to the findings There have been cases recorded in which the inflamed diverticulum was readily seen, and was excised In others there is found a mass of inflammatory tissue and the wall of the cæcum itself is acutely inflamed The best procedure for the latter condition is to exteriorize the bowel, with subsequent excision and finally closure This is a protracted and irksome experience for the patient but there appears to be no alternative

Diverticula of the Appendix

Diverticula of the appendix may be demonstrated in about ½ per cent of appendices removed at operation They may be associated with generalized diverticulosis of the colon or may result from disorganization of the appendix musculature as a result of chronic fibrosis They are not in themselves of any notable clinical significance

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PART III—THE THORAX

T. HOLMES SELLORS

CHAPTER XVII

THE LUNGS AND PLEURA

INTRODUCTION

One of the most dramatic advances in modern medicine is the application of surgery to the treatment of disorders of the heart. This field, which was considered closed to the surgeon until recently, has progressed by leaps and bounds since it was established that anastomosis between great vessels and operations on the valves of the heart were practicable. Congenital lesions of the heart and some valvular conditions are now accepted as within the routine scope of cardiac surgery, and a mass of experimental work, largely from North America, suggests that the possibilities of treatment are by no means exhausted.

In pulmonary surgery there is also an increasing volume of work, mostly in connection with cancer and pulmonary tuberculosis. In this field the principles established eight or ten years ago have hardly changed, though the technique and results have improved considerably. Chemotherapy has come to play an important part in the treatment of suppurative conditions of the lung and pleura and has influenced the use of surgery in the treatment of pulmonary tuberculosis to no small extent. Resection of lung is now accepted as a recognized form of treatment in phthisis.

Another significant feature in thoracic surgery in Great Britain is the great increase of fully trained specialists in this work. The demand for surgical treatment in pulmonary tuberculosis has contributed to this development and the thoracic surgeon and his team is taking a prominent place in both chest medicine and surgery. It is erroneous to regard the thoracic surgeon as a specialist in the narrow sense of the term, since he has to deal with nearly all systems of the body: bone, lung, œsophagus and stomach, heart and great vessels and certain nerves are all included, so that it would be better to refer to him as a general surgeon working within certain anatomical confines.

The ancillary branches of anæsthesia and physiotherapy are essential to modern thoracic work. Both these are becoming more and more specialized with the increasing volume of work and the task of the surgeon has correspondingly been simplified.

Anæsthesia

Thoracic surgery owes a great deal to modern anæsthesia which with improved methods and new drugs has simplified the course of the actual operations. Endotracheal intubation and endobronchial blocking have enabled the anæsthetist to exclude the lung of the operation side from the anæsthetic circuit so that the unaffected lung can be fully oxygenated at the same time as the anæsthetic gases are administered. In addition the mediastinum can be prevented from being adversely displaced and harmful secretions can be sucked out of the bronchial tree. Thoracic anæsthetists in this country are expert bronchoscopists and they use this procedure freely in the placing of endobronchial apparatus and sucking out secretions during and after operation.

The effect of posture during the operation has been recently discussed by the writer (1952). The advantages of the face down or prone position have been put forward by Parry Brown (1948) and by Overholt (1949) who favour this posture for lung operations.

Barbiturates such as thiopentone are freely used in conjunction with muscle relaxants so that the amount of anæsthetic gases can be reduced. Ether and cyclopropane have the disadvantage of being explosive which precludes the use of diathermy and in many clinics gas oxygen only is used in conjunction with basal agents. Intravenous procaine or one of its allied derivatives is becoming increasingly popular particularly in cardiac surgery where its effect is to reduce irritability of the heart muscle.

The main principles of thoracic anæsthesia are to maintain full oxygenation of one lung during operation and to use a controlled form of anæsthesia which lets the surgeon operate in comfort without the harmful effects of an open pneumothorax becoming apparent.

Physiotherapy

Physiotherapy is essential if quick and adequate recovery of lung function is to be obtained. Exercises based on active *inspiratory* efforts are taught before operation and then continued afterwards in spite of discomfort with increasing intensity and effort. In a satisfactory case the operation side will be expanding equally with its fellow within a week or ten days and if the chest wall and

diaphragm move normally the lung function will follow suit. No chest surgery can be efficient in the absence of a trained team of physiotherapists who co-operate with the nursing staff in post operative treatment and rehabilitation.

Recovery of thoracic function is also aided by allowing the patient out of bed at an early stage. For example after the operation of pneumonectomy if there is no untoward occurrence the constitutional disturbance is so slight that the patient can be allowed out of bed in forty eight hours and be fully dressed in a week. At the end of two and a half weeks to three weeks the patient without complications is able to leave hospital with an erect posture to continue his convalescence and rehabilitation. The main point to remember is that a chest operation does not interfere with the abdomen and legs and the ordinary posture adopted in bed can easily be detrimental and lead to kyphoscoliosis unless most careful nursing and physiotherapy are used.

A number of factors have contributed to the safety of thoracic operations—careful assessment and prolonged pre operative treatment improved technique modern anaesthesia blood transfusions chemotherapy all play their part with the result that the immediate operative mortality is surprisingly low. Antibiotics notably penicillin have provided an excellent cover against pleural and pulmonary infection. Few major operations are performed without a blood transfusion varying between 1 and 3 pints.

Post operative complications take their toll particularly in aged and toxic patients but chest complications (except in lobectomy) are uncommon and venous thrombosis with pulmonary embolism is almost unknown. There are obvious added risks in cardiac surgery but here also the recovery rate is satisfactory and the operative mortality low.

PLEURAL INFECTION

Infections of the pleural cavity have been considerably influenced by the introduction of antibiotics. In the first place the incidence of the primary cause—pneumonia—has been markedly reduced and the number of empyemata has correspondingly fallen. On the other hand the sterilizing effect of antibiotics notably penicillin has caused many practitioners to overlook the importance of obliterating the pleural cavity by means of early and efficient re expansion of the lung. A thick walled empyema with sterile contents has often provided an avoidable problem for the surgeon.

Empyema often demonstrates the unfortunate example of the

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failure of medicine and surgery to co operate The diagnosis and early treatment are in the hands of the physician who sometimes refers the patient to the surgeon only when the condition is becoming chronic In the days before chemotherapy drainage was the basis of treatment and was urgent on account of the toxæmia produced by retained pus At the present time the efficient sterilization of the pus by antibiotics may lead to a sense of false security unless the lung is re expanded at the same time

The stages through which pleural infection passes have a definite relationship to treatment The first effect of bacterial invasion is to produce an effusion which may teem with pyogenic organisms and the whole pleural membrane is potentially involved If air is admitted through an injudiciously used aspirating needle the lung will retract from the chest wall particularly at the apex, and a total empyema result Within a few days effusion becomes turbid and fibrin tends to be precipitated from the effusion which contains a variable amount of fibrinogen This stage can be conveniently referred to as *diffuse suppurative pleurisy*

As the condition progresses the pus thickens and the fibrin deposit forms a layer over the chest wall and over the lung surface At the edges of the cavity the lung and chest wall are in contact and the condition can be referred to as a *localized pleural abscess* Later the wall of the abscess or empyema becomes firmer and the fibrin organizes into a sheet which is usually two or three times as thick on the chest wall as over the lung Later cicatrization contracts the chest wall bringing ribs closer together and restricting thoracic movement at the same time the lung is tied down by this scarring

Many pyogenic cocci produce fibrinolytic enzymes which prevent excessive deposition of fibrin but if the organisms are killed by the action of penicillin this enzyme effect is removed and fibrin remains unaffected It is for this reason that penicillin treated empyemata develop unduly thick walls One method of treatment is based on the introduction of fibrinolytic enzymes such as streptokinase or streptodornase which have some solvent action on the fibrin

Treatment

The principles of treatment are governed by the stage of the infection Early diagnosis is not always straightforward as the clinical and radiological signs of the lung infection often obscure the pleural effusion but conclusive evidence is afforded by the withdrawal of fluid by the aspirating needle The character of the pus and its bacteriological content is rapidly estimated, and here a direct microscopic smear may give better information than a culture

The pleural fluid is then aspirated completely, but without admitting any air which might convert a localized pocket into a total empyema A two way tap and well fitting needle and syringe are necessary for the aspiration, which must be repeated as often as fluid collects This may mean aspiration every day or every other day and not a casual aspiration at irregular intervals Efficient aspiration removes pus and encourages the collapsed lung to re expand

Frequently aspiration fails because the pus is too thick or diagnosis is made too late The treatment of a pleural abscess depends on



Fig 68 Empyema Untreated case of total pleural infection with tension phenomena showing severe displacement of the mediastinum

the state of the contents If there is infection *open drainage* following rib resection is the correct course The tube remains in the cavity until the lung has fully expanded and the two pleural surfaces are in complete apposition This process is aided by intensive breathing exercises which must be persisted with from the onset until the final healing The disadvantage of open drainage is that some degree of secondary infection will result and delay healing

A sterile abscess does not necessarily require drainage If the contents can be fully removed by aspiration breathing exercises may allow the lung to re expand and in fulness of time the fibrin

wall will absorb This is possible in children and in early cases in which the fibrin has not seriously restricted the chest wall movements It is impracticable if there are masses of contained fibrin and pus and if the walls of the empyema are rigid In this latter event a preliminary trial of *streptokinase* injections can be made

The technique is to aspirate as completely as possible and to inject on alternate days 200 000 units of streptokinase with 70 000



Fig 69

units of streptodornase The liquefied contents are aspirated twenty four hours after the injection This method though extremely satisfactory in treating clotted hæmothorax has only a limited success in the case of empyema Trypsin is another agent used for biological decortication 250 000 units are injected into the empyema which has been previously emptied as completely as possible A buffered alkaline phosphate solution is used to maintain the correct pH and the dissolved products are aspirated fully after twenty four hours and the injections repeated for four to seven consecutive days Antihistamine drugs should be used to control any sharp constitutional reaction

If there are masses of retained fibrin or if loculation is present streptokinase or trypsin should be given only a limited trial and if these fail a limited *thoracotomy* should be performed and a complete pleural toilet carried out ensuring that all foreign matter has been removed If the walls of the cavity are not too rigid the skin



Fig 70

Figs 69 and 70 Pleurograms Radio opaque oil injected into an empyema space gives accurate information as to size and shape The ring marks the position of the tube opening on the skin Lateral as well as antero posterior views are essential

only is sutured should there be any recrudescence of infection the insertion of a drainage tube is a simple matter

Where the empyema is chronic say eight weeks from the onset and the contents remain sterile a more extensive thoracotomy is used and after emptying the contents *decortication* of the lung is carried out If the lung has been tied down by the fibrin coat it will expand as it is being freed and if suction drainage is used the lung will be rapidly expanded and the space obliterated *Pleurectomy* which involves excision of both parietal and visceral aspects of the empyema is a more popular operation It requires a major thoracotomy exposure so that the corners of the empyema and

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diaphragmatic surfaces can be excised Two or three suction tubes are used until the lung is fully expanded

These excision operations are often valuable, but may be used too freely to the exclusion of adequate physiotherapy In units where these latter are efficient the necessity for major operations is slight

Chronic Empyema

In long standing empyema there is usually a straightforward cause for the persistence of the pleural dead space This can be remedied by adequate and continued drainage with adequate physiotherapy over a period of weeks or months, except in the case of tuberculosis infection or empyema produced by carcinoma Major operations such as Schede's thoracoplasty or mutilating pleuro plastic procedures are practically never necessary The causes and treatment of chronic empyema were discussed by Sellors and Cruickshank (1951) in an analysis of 622 cases, and it was significant that delayed or inadequate treatment was responsible for the condition in 448 instances The establishing of adequate drainage and the full use of physiotherapy were successful in curing 513 cases, the remaining 100 being treated by pleurectomy, muscle grafting or other more major surgical procedures

PULMONARY SUPPURATION

Bronchiectasis

There has been little change in the attitude to the treatment of bronchiectasis in recent years Emphasis is still laid on conservative treatment and the preparation of the patient for operation by physical measures particularly breathing exercises and postural drainage The value of antibiotics in reducing the infectivity of sputum is admitted but their importance should not be exaggerated nor should they be used for a prolonged period If surgical treatment is not practicable regular and continued postural drainage should be considered This can be carried out by leaning over the side of the bed or lying on a double inclined wooden plane (which can be made by any carpenter) covered by a mattress if the patient can manage this, and many find themselves quite capable of doing so, several hours of postural treatment are possible during the night The elimination of gross oro nasal sepsis is very necessary but extensive drainage operations on the sinuses are avoided if possible

Surgical Treatment Lobectomy or lung resection is the only possible curative method in established bronchiectasis, and if the

disease is confined to part of one lung excision of that diseased lobe or segment will cure the condition If, however the disease is more diffuse any surgery which involves bilateral operations or the removal of scattered segments does not always give such a good result The patient may well be relieved of a great deal of cough and expectoration, but will still have a 'wet' chest with some sputum Removal of one segment or lobe produces little effect on respiratory function, indeed the removal of toxaemia with the excised tissue results in considerable constitutional improvement Two lobes or one lung can be excised without undue loss of



Fig. 71 Postural drainage showing the position to be adopted over the edge of a bed for draining the lower lobes

respiratory efficiency A child can even play games, but if the excision has to be bilateral the loss of lung tissue may give rise to some physical limitation The limit to which resection can be taken is reached if both lower and middle lobes are removed children can survive in moderate comfort on two upper lobes only, though their fate in later life is not yet determined

The mortality of lobectomy is low probably under 3 per cent but the post operative course is sometimes complicated by atelectasis on the operation side and, in increasingly rarer instances by bronchial fistula and pleural infection The former can be remedied by urgent postural drainage or by bronchoscopy, the latter usually requires drainage if pleural aspiration and antibiotics fail A

straightforward lobectomy should not have to be retained in hospital for more than two and a half to three weeks after operation, though the period of preparation may well have taken an equal time

No surgery is possible without satisfactory bronchograms, and increasing experience with these is producing much better results than it did a few years ago Water soluble agents are sometimes being used instead of an iodine containing oil, these substances are more irritant and do not give such good "pictures but they



Fig 72 Bronchogram Bronchiectatic changes are visible in the middle lobe The remaining lobes are normal

are absorbed quite quickly and leave no residual radio opaque shadows

Lung Abscess

Possibly the most dramatic change in the handling of any condition in thoracic work has been the treatment of lung abscess The subject which from the aetiological aspect has been admirably described in a monograph by Brock (1952) has been completely changed in incidence and in method of treatment since the introduction of antibiotics Before that period drainage of an obstructive abscess, and even excision of a lobe or lung was frequently necessary



Fig 73

Fig 74

Figs 73 and 74 Obstructive lung abscess following an operation under general anaesthesia (a) Abscess cavity with fluid level treated by intensive chemotherapy (b) Resolution obtained two months from the onset

and these procedures carried an appreciable mortality Drainage can now be considered as practically obsolete, chemotherapy having changed the whole course of the condition At the same time the incidence of these abscesses has appreciably diminished and the stinking fœtid types are uncommon

Treatment As soon as the abscess is diagnosed massive chemo therapy should be inaugurated Small doses of penicillin are ineffective, but if a daily dose of two to four million units is given and continued for three to four weeks or more a favourable result is almost certain Often in the early stages there is little apparent response to treatment, but this should not lead to an alteration in policy The organisms in the sputum are rarely sensitive *in vitro* to penicillin but penicillin should be used unless, as in the case of *B Friedlanderi*, there is a clear indication to use streptomycin

After the acute stage of the illness has passed the abscess may disappear or leave a residual cyst like space usually associated with some bronchiectasis If a thin walled ' cyst persists recrudescence of infection may occur at a later date or if there are any untoward symptoms a segmental resection can be practised when the patient has recovered from the ill effects of the primary lesion Emergency operations on fulminating suppurative lung lesions carry a high mortality in spite of chemotherapy, blood transfusions and modern technical methods

PULMONARY TUBERCULOSIS

The main recent feature in the treatment of pulmonary tuberculosis has been the advent of effective chemotherapy Streptomycin para aminosalicylic acid (P A S) and now isoniazide have all been shown to be of value in certain phases of the disease They also have played some part in ensuring safer surgery particularly when lung resection is practised

Collapse Therapy

The surgical treatment of pulmonary tuberculosis has shown a steady increase in controlling the most stabilized aspects of the disease Collapse therapy can be used to close cavities and to reduce the adverse effects of fibrosis thoracoplasty has become increasingly popular in this respect The efficiency of this selective and permanent form of collapse has been established from a study of the long term results For example in the writer s series (1947) of 633 patients who were followed up more than 81 per re

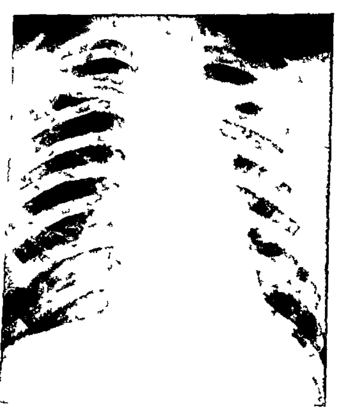


Fig 75



Fig 76

Figs 75 and 76 Thoracoplasty for large left apical cavity with disease extending through most of the upper lobe The collapse obtained obliterates the cavity but preserves some basal function

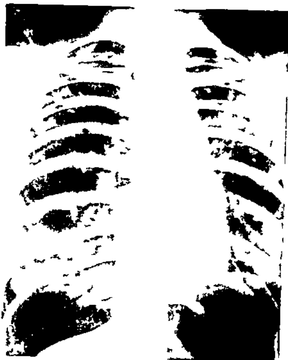


Fig 77



Fig 78

Figs 77 and 78 Left apical cavitation treated by extensive apicolysis with implantation of lucite spheres to maintain the collapse Bird cage type of operation Though the ribs are left intact the periosteum and intercostal muscles are stripped free and left attached to the lung as the apicolysis is performed

considered satisfactory, and the operative mortality was only 2 7 per cent

In addition to thoracoplasty there has been a fluctuating vogue in extrapleural operations Extrapleural pneumothorax has still its advocates, but there have been a number of modifications of the apicolysis procedures which aim at preserving the rib cage and maintaining the collapse of lung with an artificial substance For example Morriston Davies (1951) introduced a polythene pack to hold the apex down and has recorded 97 cases in which this operation was used A variety of osteoplastic operations in which the periosteum and muscles are freed from the ribs and allowed to fall down with the freed apex have been described The dead space so formed has been examined with a variety of substances such as lucite or polythene balls Lucas and Cleland (1950) describe the successful use of this 'bird cage' type of operation in 125 cases with three deaths and good results in the early follow up, there were only five examples of post operative spread The practice of combined phrenic nerve interruption and pneumoperitoneum is still popular where surgery is not readily accessible but on the whole it is not so popular as in the immediate years after its introduction

Resection

The most recent addition to surgery has been the increasing use of lung resection in the form of segmental removal lobectomy or pneumonectomy and this type of operation has had considerable popularity in some clinics In many records from the United States and in some from this country it would appear that thoraco plasty and collapse have been practically abandoned in favour of resection There are two schools of thought as regards resection the one in which resection is regarded as an efficient form of treat ment for comparatively limited disease and in which it has super seded collapse operations The other school adheres to collapse measures which in the past have given and continue to give good results reserving resection for cases in which collapse has failed or is impracticable It is of little value trying to compare the results of the two schools since the selection of patients suitable for surgery differs too widely

The problem is a complex one and there is a matter of principle involved concerning how much tuberculous disease is to be removed or should be removed from the body If the disease is regarded as a general condition with a local manifestation then only mechanical disabilities such as cavities or stenoses should be treated but where tuberculosis is regarded principally as a pulmonary condition

the enthusiasm for excision of any focus of disease is likely to be greater

The average practice in this country is to regard resection as an additional procedure where collapse has not been successful or would not be suitable Commonly accepted indications could be classified as follows —

1 Tuberculoma which is a generic term to cover several pathological conditions and is really a radiological diagnosis It

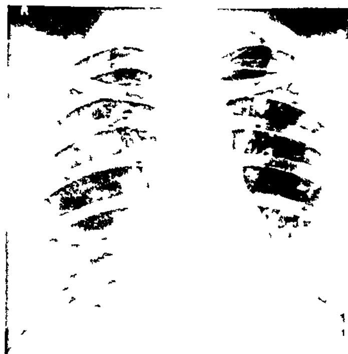


Fig 79 Tuberculoma in right upper lobe

includes such conditions as solid foci inspissated cavities and some primary foci These are potential dangers in the future if there is a tendency for them to cavitate and to spread

2 Cavities unsuitable for collapse such as those in the apex of the lower lobe where pneumothorax and phrenicectomy have failed

3 Cavities persisting under thoracoplasty A well executed thoracoplasty sometimes fails to close a large cavity which remains as a pear shaped slit

4 Broncho stenosis which is one of the few conditions in which

the tuberculous patient may produce much sputum Here collapse would be of little value Excision undertaken for bronchostenosis may well lead to pneumonectomy because of gross adhesions to the chest wall and between the lobes

5 Destroyed lung in which the disease process has progressed in spite of conservative measures or in which the lung has been so



Fig 80 Tuberculous cavities in the apex of the right lower lobe Lobectomy was successfully undertaken after the acute phases of the disease had been controlled by rest and chemotherapy

destroyed by cavitation that it is functionally valueless and a danger to the patient

Danger of excision is that once inside the chest a more extensive operation than that planned may develop sometimes for technical reasons more often because a great deal more disease is actually palpated in the lung than was suspected from the radiographs It is impossible for the surgeon to tell which nodules of disease are dangerous to leave behind and which areas should be removed The chief complication of the operation lies in tuberculous infection of the draining bronchus which when cut across will not heal as readily or securely as for example in lobectomy for bronchiectasis

The risk of bronchial fistula and a tuberculous empyema is therefore present and with it the knowledge that a bad result will follow unless this can be remedied Early expansion of residual lung is very important, and one or more drainage tubes to which suction is applied are used to aid re expansion of lung Some form of thoracoplastic collapse is commonly used to avoid over distension of lung tissue or to close down a potentially infected dead space



Fig 81 Tuberculosis Destroyed right lung treated by pneumonectomy

Tuberculous empyema often follows a badly chosen pneumothorax which develops fluid and is a formidable proposition The intense fibrosis of the tuberculous process freezes or fixes the chest wall and the constricting visceral layer prevents re expansion of the lung If repeated aspirations fail to induce re expansion of the lung much more drastic treatment will be required If the underlying lung is diseased a difficult and tedious thoracoplasty in several stages will be needed to obliterate the space but even this may fail in its object Decortication or pleurectomy can be undertaken in con

junction with an apical thoracoplasty if the lung is relatively sound, but this is not always successful and the operation is rarely straight forward Possibly the most satisfactory operation when the lung is damaged is a pleuropneumonectomy, as described by Sarot (1949) The whole pleural sac and lung are removed and the space closed by a later thoracoplasty The operation is admittedly severe and produces a considerable degree of shock, but it provides the only solution to a number of cases and is favoured by the fact that tuberculous infection of the space does not often recur, and if it does it is not as significant as if it occurred in the original space

CANCER OF THE LUNG

Cancer of the lung or more correctly bronchial carcinoma, is now recognized as one of the most formidable problems in medicine The incidence of the disease is alarming, and the figures for cancer deaths in Britain show that lung cancer is second only in frequency to carcinoma of the stomach and is more common than malignant disease of the breast

The Registrar General s figures show that over the period 1939–48 deaths reported as being due to pulmonary cancer have more than doubled The accompanying table illustrates this sinister increase in relation to some other causes of death

	1938	1943	1948
Total deaths from cancer	68 799	74 010	81 514
Cancer of stomach	12 833	12 845	14 448
Cancer of LUNG	4 658	6 530	10 463
Cancer of breast	6 832	7 410	7 907
Deaths from pulmonary tuberculosis	21 282	21 082	18 798
coronary disease	15 409	20 456	36 640

The percentage in lung cancer mortality has risen in men from 1 5 in 1916 to 7 9 in 1935 and from 0 8 to 2 2 in the same years in women

The reasons for this growing figure are not only due to greater awareness of the condition and improved radiological facilities but also to an actual increase Many theories have been advanced to account for this disquieting feature, but the only ones that have any statistical basis are smoky atmosphere and the effect of heavy cigarette smoking The work of Bradford Hill and Doll (1950 and 1952) in this country has shown that a person who smokes fifteen or more cigarettes (not pipes or cigars) a day over a period of years

is at a considerably greater risk than a non smoker Figures from the United States tell the same story No further explanation for this predisposition has been advanced though insecticides and other components of the cigarette have been studied Workers in contact with chromium products are accepted as being vulnerable, and the incidence of the disease is much higher in smoky atmospheres than in more sunlit coastal areas If the increase has to be accepted the responsibility of the profession in recognizing cases in which

PLEURAL

EFFUSION	PAIN
CHEST WALL	DYSPNŒA

BRONCHIAL

ATELECTASIS	COUGH
BRONCHIECTASIS	SPUTUM
ABSCESS	DYSPNŒA
	TOXAEMIA

MEDIASTINAL

VENOUS OBSTRUCTION	
AURICULAR FIBRILLATION	
NERVE INVOLVEMENT	
	LOSS OF VOICE
ATELECTASIS	DYSPNŒA

FIG 82 Relation of signs and symptoms to the site of the growth

treatment is *possible* is clear and the only hope of *improving the* present situation is to diagnose the condition at a much earlier stage than at present

One of the first things is to realize that the average textbook description of lung cancer is the description of advanced and almost certainly inoperable disease In the early case clinical signs and symptoms may be absent or minimal and the diagnosis can only be made by radiology Mass miniature radiography routine screening of students and nurses screening of the chest during a barium meal provide a number of operable cases, but these

"accidental" discoveries are only a small proportion of the total Any untoward chest sign or symptom must be fully investigated if the early stages of the disease are not to be overlooked, and this includes chest radiography

The signs and symptoms are variable in the extreme and depend on the situation of the growth For general purposes three main groups can be considered —

1 Lung Fields

If the growth arises in the middle of the lung it may reach a considerable size before producing any symptoms The clinical



Fig 83 Abscess in the apex of the lower lobe produced by a squamous celled carcinoma

features will depend on bronchial obstruction An irritant and non productive cough is produced by pressure on a major bronchus but more definite signs will result if the bronchus is occluded and atelectasis follows This does not lead to much disturbance in the absence of infection though sudden atelectasis gives rise to shortness of breath Infection will lead to the clinical picture of pneumonia and the diagnosis of "unresolved pneumonia" is

frequently a misnomer for carcinoma Bronchiectasis can occur, also abscess Abscess formation may be one of two types—a break down of the actual growth, or a more peripheral obstructive abscess Hæmorrhage from ulceration of the growth is sometimes the first sign of the condition and should never be ignored no matter how slight Frequently the sputum is stained for several days on end even if this is slight it should always be regarded as a highly suspicious feature

2 Pleural Area

A growth close to the chest wall may produce the pain of pleurisy and in many cases an effusion develops In the early stages this

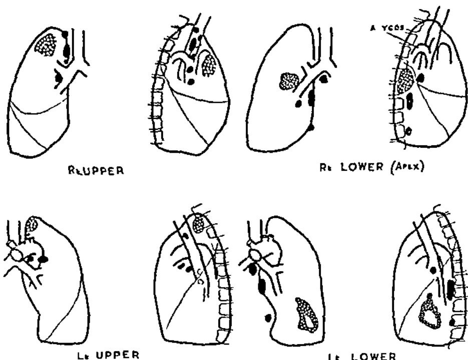


Fig 84 Fig 85

Figs 84 and 85 Glandular involvement in carcinoma of the lung In the upper lobes the paratracheal group on the right and the subaortic on the left are important

In the lower lobes the subcarinal and œsophageal glands are the most frequently affected of the extra pulmonary nodes Interbronchial glands are invariably involved if the extra pulmonary groups are invaded

effusion is often clear but if the membrane is heavily involved the effusion will be bloodstained Frequently pleural adhesions develop over a wide area so that the lung is fused to the chest wall On the

other hand, the tendency of the growth is to spread along the pleural planes and not to break through into the chest wall

3 Mediastinum

The variety of signs produced by invasion of the mediastinum, usually by glandular metastasis, is extreme Obstruction of the superior vena cava or left innominate vein results commonly from gland pressure Loss of voice suggests involvement of the left vagus or recurrent laryngeal nerve Paralysis of one half of the diaphragm can be produced by invasion of the phrenic nerve anywhere within the thorax Difficulty in swallowing can be caused by displacement of the œsophagus, which is a feature which should routinely be checked by a barium swallow Auricular fibrillation can be caused by spread of growth along the pulmonary veins and its sudden recognition in a man who has had no previous history of heart disease should lead to the suspicion of a lung growth Any one of these features means that the growth is probably inoperable even though it is the only and earliest sign

General Condition

The traditional description of cancer can easily be applied to bronchial carcinoma in the terminal stages but the average early case shows none of these features indeed, if the patient has lost weight or is unduly lethargic and ill looking the possibility of an advanced condition should be considered Admittedly, a patient whose growth has led to obstructive features with suppuration will show signs of secondary infection which are sometimes dramatically improved by chemotherapy Emaciation and ill health in the presence of a small pulmonary shadow can be caused by invasion of the suprarenal glands by secondary deposits, and this is one of the more common sites for metastasis Distant secondaries can occur anywhere but there is a predilection for brain and bone in addition to the suprarenals

Recently a number of examples of arthropathy have been shown to be associated with the disease, and are remarkable in that the symptoms of the joint condition resolve within a few hours of the growth being removed The most common form is clubbing with pulmonary osteo arthropathy, but practically any form of joint disease may be encountered and routine radiography of the chest should be considered in all patients in whom there is a sudden onset of arthritis Similarly, one of the early general features may be a neurological condition again with no constant pattern, but one in which a diagnosis is difficult to determine

Diagnosis

Bronchial carcinoma is essentially a disease of middle aged men, but no age or sex is exempt and patients of twenty and thirty years can be victims of this condition The safe attitude to adopt towards a patient with any unexplained radiological shadow is to suspect a cancer until proved otherwise Real difficulty may arise in differentiating a growth from a tuberculoma and in recognizing a growth in a mass of inflammatory tissue Repeated radiography at two or three week intervals while the patient is undergoing a course of chemotherapy may show some resolution of inflammatory shadows but even this is not conclusive unless the shadow completely disappears Even at thoracotomy it may be impossible to establish the diagnosis

Bronchoscopy is an important diagnostic method, but has limitations particularly if the growth is peripheral to the larger bronchi It is invaluable in cases where the growth presents in the major bronchi and where a biopsy can be taken Investigation of the sputum for cancer cells is a diagnostic method of great value in the hands of experts, and should be used in cases of doubt or when bronchoscopy is negative or indefinite

Pathology

It is customary to divide bronchial growths into four headings three of which are undoubtedly malignant and the fourth which shows local invasive characteristics The three groups are classified largely according to the predominant type of cell —

1 Squamous cell
2 Columnar cell
3 Undifferentiated or oat cell
4 Bronchial adenoma

Squamous cell tumours favour the larger bronchi and frequently lead to hæmorrhage and obstruction with atelectasis They are visible on bronchoscopy and are often favourable for treatment Columnar cell carcinoma is usually peripherally placed and rounded giving the appearance of being almost encapsuled It does not produce many secondary complications and if not attached to the chest wall is capable of removal /Undifferentiated or oat cell growths are much more dangerous They appear in the submucous tissues of the bronchus leading to stenosis of a rat tail type rather than a transverse one they infiltrate and are particularly deadly because of the simultaneous appearance of hilar

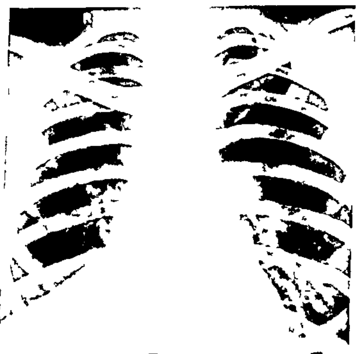


Fig 86 Carcinoma of lung Collapse of right lower lobe produced by squamous cell growth



Fig 87 Carcinoma of lung Peripherally placed adeno carcinoma in the right upper lobe with enlarged para tracheal glands

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or 5,000 r without ill effect Others, particularly heavier built patients, suffer considerable sickness, loss of appetite and weakness

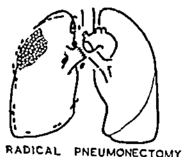
Surgery Incision in cancer of the lung can be divided into radical and palliative forms In the former the growth is excised *en bloc* with the whole of the glandular field, this requires complete removal of the lung and the hilar glands Palliative resections which often yield good results are used when the more extensive operation is contra indicated For example, in an elderly man with poor lung function and a small growth a lobectomy is preferable to a more thorough operation which would leave the patient short of breath It is not so much the question of operative shock that makes the distinction between the two, but the actual question of loss of lung tissue in a patient with impaired respiratory function

The selection of patients for operation has to be judged under two headings —

1 Situation, size and type of growth

2 The general condition of the patient with special reference to respiratory function

To illustrate these points one can take the example of a small growth in the middle of the lung field in a young or healthy middle





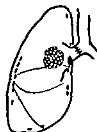


FIG 88 Types of operation available in carcinoma of the lung Radical pneumonectomy includes excision of the mediastinal pleura and all subjacent lymph nodes The vessels are secured within the pericardium Lobectomy is permissible where the growth is limited in size and where the patient will not withstand loss of the whole lung In all instances the divided bronchus is cut as close to the parent stem as possible

aged patient Here the chances of success are considerable At the other extreme is a large growth close to the mediastinum in an emphysematous elderly man with bronchitis Mediastinal involve

glands which invade and produce pressure on the great vessels and main bronchi Bronchial "adenoma" is a tumour of great pathological interest whose nature is not finally determined It would appear to be derived from the mucous glands of the bronchi and produces a circumscribed type of tumour which frequently causes early obstruction of a bronchus and hæmoptysis On rare occasions it is said to produce metastasis but the tendency is to regard it as a tumour of only local malignancy and to be satisfied with a local rather than radical removal

Treatment

It is generally agreed that the only form of treatment which holds out any hope of success is surgical excision Considerable use is made of radiotherapy but there are few examples in which the treatment has done more than palliate the symptoms and in spite of new techniques it does not appear that radiotherapy is likely to replace surgery Its future may lie in combination with surgery either as a pre or post operative measure and it clearly has to be considered when surgery is contra indicated

The regrettable feature of surgery is that it is only applicable to a limited number of patients The figures for operability given by surgeons bear little relation to the true state of affairs as these are usually taken from a selected group of patients who have been considered fit to be seen by the surgeon If the total incidence of pulmonary cancer is taken into account it is probable that somewhere between 12 and 15 per cent will be accepted as suitable for operation and in only two thirds of these will the growth be capable of removal

Radiotherapy The original technique in which a heavy direct field was used over the growth has given place to a multiple field technique in which the rays through small ports of entry are directed so as to intersect on the area of the growth and in this way a concentration at the correct site can be achieved without damaging the skin and underlying tissues too seriously If too heavy a dose of deep X rays is given a severe form of lung fibrosis results with most distressing dyspnœa Pneumonitis is not an uncommon sequel but it usually responds to massive chemotherapy

Radiotherapy is undoubtedly of great value for alleviating pain due to bony invasion or metastasis and it frequently reduces hæmoptysis On the other hand it cannot be used in the presence of sepsis which is common when a bronchus is obstructed nor can it be used in association with tuberculosis Some patients tolerate a treatment, given in doses of 200 to 300 r of up to a to[illegible] 4 000

the development of a bronchial fistula usually between the tenth and fourteenth day, the contents of the hemithorax are coughed up, and if the fistula persists infection of the empty pleural space will follow Antibiotics and repeated aspirations sometimes succeed as a method of treatment, but more usually drainage followed by an extensive thoracoplasty is needed to obliterate the infected space and close the fistula Bronchial fistula is much less common than in the early days of pneumonectomy, but its occurrence serves as a reminder that the technique of bronchial closure is not perfected

After pneumonectomy the empty space partly fills in with bloody effusion from which fibrin is deposited This organization of the effusion reduces the volume of the space considerably and is aided by displacement of the mediastinum, elevation of the diaphragm and flattening of the chest wall Final obliteration of the space occurs within six to nine months of the operation and by this time the mediastinum is considerably drawn over Some surgeons regard this displacement as a harmful procedure and suggest that a thoracoplasty should be performed to stabilize the upper mediastinum In this country it is felt that this alteration in the position of the mediastinum is well tolerated and does not require treatment

The immediate effects of a successful pneumonectomy are surprisingly slight The average patient who is walking about within a week of operation can leave hospital in two to three weeks and often returns to work in less than the same number of months Ordinary activities are well tolerated though there is naturally some limitation on heavy exertion A shopkeeper, a clerk and a professional man will be able to continue with normal work though a labourer might well be advised to find a lighter form of occupation

Results When it is considered that pneumonectomy is a comparatively recent operation and the more radical forms of operation have only been practised within the last four or five years the results are not too disappointing particularly as early operable cases are the exception rather than the rule The figures given by Brian Taylor and Waterhouse (1950) are as fair a summary as any of current practice In a series of 1,134 cases collected from a number of British surgeons the operative mortality was 24 3 per cent 41 per cent survived the operation by more than six months and the five year survival rate was 14 per cent If the operative mortality group was excluded the average period of survival after operation was twenty months this contrasts with a four month survival rate in patients who were not submitted to pneumonectomy

ment is always an unhappy event and many investigations still have to be made to decide whether the patient could support loss of the whole of one lung in some cases with impaired respiratory function a more limited operation may not only be feasible but be the correct and appropriate procedure Some operations may fail to eradicate the growth and glands but in spite of this they may give good results and above all save the patient from the effects of sepsis and early pressure phenomena

Radical pneumonectomy consists in removing the whole glandular field with the lung the individual hilar vessels being secured within the pericardium The dissection will start at the top of the mediastinum and be continued down to the pulmonary ligament to include every gland At the same time if the lung is adherent to the chest wall an extrapleural dissection will be made

Dissection and division of the bronchus must in all cases be made so that no pocket or stump is left behind In other words, the main bronchus is cut so that the lower end is practically flush with the carina The important subcarinal gland is removed in such a way that the dissection exposes the inner wall of the main bronchus on the opposite side for an inch or so this may involve considerable retraction of the aorta on the left side The cut ends of the bronchus are closed by interrupted non absorbable sutures (seven to ten in number) after it has been ensured that the edges will come together by cutting or removing any unduly rigid cartilage rings The closure must be airtight and the suture line is reinforced with fascia pleura or adjacent tissue The use of a pedicled intercostal muscle graft cut at the time of the incision is valuable in providing a cap of living tissue over the bronchus stump

When the pulmonary vessels are dealt with the usual course is to open the pericardium and to divide the individual structures within the pericardium starting with the artery It has however been suggested that manipulation of the lung may lead to a fragment of growth being cast off into the pulmonary vein as an embolus Division of the vein central to the growth should possibly be the first step in separating the hilar structures By working within the pericardium an extra centimetre or so of vessel may be available and it is feasible to place a clamp across the auricle at the base of the veins and suture the wall of that chamber In most cases simple ligature or a transfixion stitch suffices to hold the pulmonary vessels

The operation is generally withstood satisfactorily though occasional cardio respiratory failure follows in elderly patients This is particularly noticeable in patients with previous persistent bronchitis and bronchospasm The most serious complication is



FIG. 91 Carcinoma of lung The appearance two years after excision showing the traction of the mediastinum elevation of the diaphragm and filling in of the dead space by fibrin

New Growths of the Trachea

This form of neoplastic disease offers special problems in excision since any excised area involves some reconstruction of the tube Adenoma and carcinoma are the common forms, Ellman and Whittaker (1947) having collected 120 examples of the latter Thirty four instances of sarcoma have also been recorded The immediate danger of any of these tumours is obstruction and stridor requiring urgent relief is sometimes the first symptom If not relieved the patient dies from suffocation unless a merciful pneumonia develops

Excision of the trachea and main bronchi is a practicable proposition if the amount removed is not too large From cases of ruptured bronchus it has been shown that resection of a short length followed by suture may be quite successful, and this procedure has been used in the case of localized tumours The difficulty of excising greater

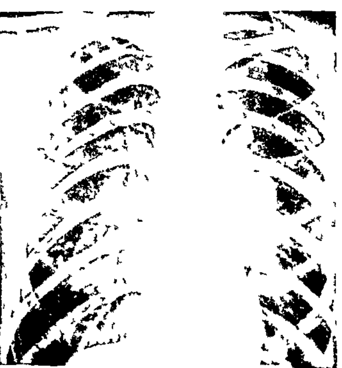


Fig 89



Fig 90

Figs 89 and 90 Carcinoma of lung Oat Cell growth with glandular involvement at the left hilum Treated by pneumonectomy

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areas of bronchus or tracheal wall is that some form of reconstructive repair is necessary if the rigid lumen of the tube is to be maintained Belsey (1950) after excising a tracheal growth used a stainless steel framework over which was placed a fascia lata graft and obtained an efficient repair Free skin or dermal grafts have also been used successfully but in all these cases some bridge of tracheal structure was left after the excision Removal of a complete section of trachea which leaves a considerable gap offers a problem that has not yet been fully solved The trachea is normally capable of considerable extension and contraction so that a rigid prothesis or tube may not be successful though a success has been recorded The writer using a stainless steel geodesically constructed spiral has had temporary successes but none of long duration

Palliative measures to prevent suffocation include diathermy and punch excision through a bronchoscope and temporary relief has been seen following the use of radiotherapy

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Acquired	Mitral regurgitation
	Tricuspid lesions
	Aortic stenosis
	Aortic incompetence
	Aneurysm of the great vessels
	Myocardial ischæmia
	Congestive heart failure

Experimental

Congenital	Transposition of great vessels
Acquired	Replacement of valves by plastic devices
	Grafting procedures

The established procedures will be considered in more detail and also some of the other methods which hold out some hope for the future

General Observations

The heart itself tolerates a certain amount of manipulation As long as it is not displaced from its bed by undue traction or pressure it does not resent touching or even incision though extra systoles or temporary arrhythmias may be observed Prolonged or rough manipulation will seriously interfere with heart action and produce ventricular fibrillation which is fatal unless promptly remedied, but given gentle handling and periods of rest the heart itself suffers little harm If in addition drugs, notably those of the procain group are used irritability is reduced and the surgeon s task made more simple The criteria for cardiac manipulation were clearly laid down by Harken (1946) when he described his war time experiences in the removal of foreign bodies In his series there were eleven instances in which he successfully removed a missile from the interior of a chamber of the heart

Vascularity of the heart muscle and the thinness of the auricles and great vessel walls suggest that any operative approach to the heart should be surveyed with the closest circumspection and only undertaken with the risks clearly envisaged A divided peripheral artery will jet forth blood but bleeding from a wound in the heart is a flood the best part of a pint of blood may be lost in a matter of seconds and a dry operating field may be converted into a veritable blood bath For this reason the use of intracardiac or intra aortic transfusions should be borne in mind they may not be necessary but they can on occasions be life saving when the whole attention must be directed in the case of a massive hæmorrhage, towards maintaining an adequate coronary and cerebral circulation

CHAPTER XVIII

SURGERY OF THE HEART

The Scope of Cardiac Surgery

THE relief of cardiac compression particularly constrictive pericarditis, has been attempted for a number of years similarly heart wounds have been secured from time to time Occasionally brilliant essays such as those of Souttar, who dilated a stenosed mitral valve in 1925, and of Tuffier, who dilated an aortic stenosis by invaginating the vessel wall with the finger have been recorded, but the dates from which the present impetus starts can be given as 1939 when Gross ligated a patent ductus arteriosus and 1944 when Blalock and Taussig published their anastomotic operation for pulmonary stenosis Since that time not only have congenital deformities been treated but acquired heart disease in the form of valvular lesions have come within the sphere of practical surgery The world literature abounds with experimental work on all aspects of heart disease and isolated instances of success in man are recorded from time to time in new fields

The lesions for which surgery can be considered may be classified under the headings of those established of undetermined character and of an experimental nature

Established

Congenital Patent ductus arteriosus
Pulmonary stenosis including Fallot s tetralogy pure pulmonary stenosis truncus arteriosus tricuspid atresia
Coarctation of the aorta
Abnormalities of the aortic ring

Acquired Injuries to the heart
Foreign bodies in the heart
Constrictive pericarditis
Mitral stenosis
Aneurysm of some great vessels

Undetermined

Congenital Eisenmenger s syndrome
Patent interatrial septum
Patent interventricular septum

should be tied snugly, but not so tightly as to cut through comparatively soft myocardial fibres The resultant scar is firm and does not lead to weakness or cardiac aneurysm

Manipulation of Great Vessels In dissecting one of the main arteries care has to be taken to avoid tearing off fine branches which emerge at right angles to the parent stem Should a short stump or opening result a large hæmatoma may develop under the adventitia which will have to be incised and reflected to expose the bleeding point Clamps should not be used to secure this , a fine arterial suture is required Veins as well as arteries can be retracted quite firmly by loop ligatures or tapes but if their walls are incised even minutely the vessel may split open for some distance when pulled on

Ligatures of thread or silk can be used to occlude any vessel up to 2 0 cm diameter, as in the case of the pulmonary arteries and veins in a pneumonectomy, but there is an increasing tendency to avoid

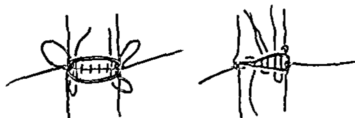


Fig 93 Arterial suture Method of obtaining end to end anastomosis with everting stitches Note stay sutures

ligature and to cut off the vessel beyond a control clamp and then to suture the open end by a fine continuous arterial stitch

Vascular anastomoses consist in freeing the required vessels over a sufficient length to allow them to be brought together without undue tension This may involve as in the case of resection of an aortic coarctation a considerable dissection The adventitia, particularly of arteries, has to be removed meticulously to prevent buckling of the vessel on suturing The actual junctions are made with everting stitches usually in short continuous runs of very fine plastic or silk material (00000) on eyeless needles, each end being secured by an interrupted stay stitch Allowance has to be made for the degree of distension of the anastomosis that occurs when the control clamps are removed over tight sutures may narrow the junction or even cut through the vessel wall stitches too loose will not make a blood tight junction Anastomoses which prove efficient bleed when the clamps are removed but after two or three minutes stop as the distending vessels pull up on to the sutures

Failure to maintain an adequate blood supply to the heart and brain for more than a minute or two may result in irreparable damage. The most specialized brain cells do not tolerate anoxia for more than forty five to sixty seconds.

Approach to the Heart Many of the approaches previously described for reaching the heart and pericardium have been abandoned in favour of antero lateral or postero lateral transpleural thoracotomy incisions. If these are sufficiently extensive there is little difference except in the posture of the patient in the degree of exposure. A fourth rib approach gives ready access to the base of the heart and great vessels while a fifth rib exposure is more suitable for the body of the heart. Longitudinal division of the sternum gives access to both sides of the heart and a bilateral intercostal incision with transverse section of the sternum has been used in a few instances to permit an even fuller exposure though this entails opening of both pleural cavities.

Once the lung has been allowed to collapse the pericardium is incised longitudinally and parallel to the phrenic nerve. At the end of the operation the pericardium should be loosely closed leaving gaps that will allow effusion to escape but which will not permit the heart to squeeze through an opening and become strangulated. This is important on the left side.

Wounds of the Heart Wounds of the heart heal readily with

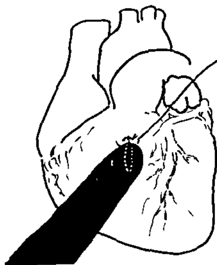


FIG. 92. Arrest of hæmorrhage from a wound or incision in the heart. *Gentle pressure of the finger controls the bleeding while interrupted sutures are placed through the heart muscle.*

simple suture. Complicated stitches to control any incision into the heart are often less effective than the direct pressure of a finger below which a deep suture can be passed. The type of suture used is not important: silk or thread is preferable to catgut and it

superior vena cava into the right atrium It is then advanced through the tricuspid valve into the right ventricle and on through the pulmonary valve into the pulmonary artery The position of the end of the catheter is controlled by fluoroscopy and pressure readings are taken at various points In the normal heart, if the catheter is passed further on it will be arrested in a fine branch of the pulmonary artery, and if at this point the catheter is withdrawn very slightly the pressure reading taken at this point is referred to as the so called pulmonary capillary pressure At any stage of the catheterization blood samples can be taken in order to measure the oxygen saturation

TABLE VIII

Typical Findings by Cardiac Catheterization in Various Forms of Heart Disease

	Superior Vena Cava	Right Atrium	Right Ventricle	Pulmonary Artery	Brachial Artery
NORMAL					
Mean pressure* (mm Hg)	1	0	10	15	120/80
Oxygen saturation (%)	75	75	75	75	96
PATENT DUCTUS ARTERIOSUS					
Mean pressure (mm Hg)	1	0	15	25	130/65
Oxygen saturation (%)	67	67	67	83	96
TETRALOGY OF FALLOT					
Mean pressure (mm Hg)	1	0	35	[illegible]	110/70
Oxygen saturation (%)	65	55	55	[illegible]	60
MITRAL STENOSIS					
Mean pressure (mm Hg)	3	2	30	40	100/75
Oxygen saturation (%)	75	75	75	75	96

* Referred to plane 5 cm below sternal angle

To illustrate some of the values of this procedure one can instance a case in which the passage of a catheter from the right atrium into the right ventricle shows a sudden rise in the oxygen saturation of the blood This suggests that oxygenated blood has reached the ventricle as would occur when blood is passing from left to right through a patent interventricular septum Again, if on passing the catheter from the right ventricle into the pulmonary artery there is a sudden fall in pressure the existence of a stenosis would be inferred On the other hand if the pressure was suddenly to rise beyond the pulmonary valve and the oxygen saturation to increase the possibility of a patent ductus arteriosus should be considered as aortic blood passes through this fistula into the pulmonary artery The

Investigations

Routine clinical and radiological investigations suffice for the diagnosis of many patients in whom surgery is contemplated There is little difficulty in recognizing a patent ductus arteriosus for example but there may be extreme difficulty in deciding on



FIG 94 Cardiac catheter *in situ* The radio opaque catheter entered through an arm vein has passed via the left innominate vein into the superior vena cava thence to the right auricle and curving sharply upwards in the right ventricle reaches the common pulmonary artery The sweep of the catheter carries it into the right pulmonary artery and the tip finally lies in one of the finer branches of the right lower lobe artery

the exact anatomical nature of the lesion in a case of congenital cyanotic heart disease Again mitral stenosis may be easily diagnosed but the extent of the obstruction and the pulmonary pressure cannot be assessed accurately by ordinary clinical methods

To assist in the solution of these problems two procedures are now available in many cardiac departments—cardiac catheterization and angiocardiography

Cardiac Catheterization In cardiac catheterization a fine polythene catheter is passed along a vein in the arm through the

equipment The speed of injection and the rapid exposure of films are essential for a satisfactory result

There are many points that can only be safely determined by this method For example not only can a stenosis be made out but its site can be identified, dilatations and abnormalities of vessels will be outlined and if anastomotic operations are in prospect the length and proximity of the requisite vessels will be seen Again if dye appears simultaneously in the aorta and pulmonary artery the inference is that there is a communication between the right and left heart

Aortography is based on a similar principle introducing a catheter through a branch of the radial artery near the elbow and passing it against the blood stream through the subclavian artery until it reaches the ascending aorta The dye is then injected again suddenly and immediate pictures may reveal the clear outline of some such abnormality as a coarctation of the aorta The procedure is not without danger unless the position of the catheter is carefully observed should it be passed too far and enter one of the openings of the coronary artery the danger of disaster with the sudden injection is apparent

TECHNICAL AIDS TO SURGERY

Extracorporeal Circulation If blood can be deflected from the heart but an active circulation maintained in the brain and heart muscle there is little reason why the heart chambers should not be opened and an abnormality repaired before restoring the normal circulation A number of investigators from different countries have devised machines which suck the blood from the patient s circulation oxygenate it fully and pump it back into the arterial system at a reasonable pressure and with a flow of at least 5 litres per minute

It is probable that permanent damage will occur in the cortical cells of the brain if there is a period of circulatory arrest or complete anoxia for more than one and a half to two minutes The heart muscle will show electrocardiographic changes (Blesingarth) if deprived of oxygen for more than five minutes Myocardial anoxia also sensitizes and predisposes the heart to ventricular fibrillation

The principle underlying the artificial heart lung is to deflect the venous return by sucking the blood out of the venæ cavæ or right atrium with a catheter after heparinization of the patient s blood The venous catheters may be introduced through the saphenous vein but are more usually passed through the azygos vein The

passage of the catheter is not always easy and several manipulations may be required to prevent the catheter sticking in one of the chambers and coiling up

Angiocardiography (introduced by Castellanos - 1937) Angio cardiography affords a visual means of studying the flow of blood through the heart Fifty to 100 ml of 70 per cent diodone is injected with extreme rapidity into a vein, and this radio opaque block of fluid reaches the heart within a second If a number of serial radiographs are taken (say eight or ten) within five seconds



Fig 9o Aortogram in Coarctation Diodone injected through catheter passed into the ascending aorta outlines the aorta and great vessels The site of aortic coarctation is defined and the coronary arteries are visualized

of the injection the films show the outline of the chambers of the heart and vessels and the order and speed with which they fill Normally within three seconds the dye will have reached the pulmonary vessels and will be returned to the left heart in five to six seconds After this though with a less intense shadow the systemic circulation will be visualized

Special apparatus is required for this technique and the pictures may be taken in whatever plane is considered most suitable

Simultaneous two plane pictures taken at high speed as practised by Lind and Wegelius are of value, though they require elaborate

by giving the heart a powerful electric shock (2 amp per half second repeated three or four times is an average) between two large electrodes These electrodes if shaped like suction cups can also be used for cardiac massage as suggested by Beck, who has elaborated a technique for resuscitation of cardiac arrest

The disadvantages of the artificial heart lung are many the machinery is complicated it is difficult to avoid gas bubbles which may obstruct the smaller coronary vessels and it is elaborate to set up in a patient with an already defective heart It has been used in man on a few occasions with limited success

An extracorporeal unit of animal origin has also been considered In this blood is pumped through a monkey s lungs which maintain adequate oxygenation, and if immunological reactions can be avoided this would appear a possible solution Mustard and Chute (1951) have used this method in babies but without permanent success

Hypothermia The hibernating animal associates a very slow heart rate with its depressed metabolism and experiments have been carried out to produce this effect by cooling off the patient This can be achieved by cooling down the whole body under anæsthesia, using curare or muscle relaxants to avoid shivering When the body temperature is depressed to 20° C the heart beat is so slow and the circulation so inactive that the heart can be opened and its interior inspected The operation consists of a right thoracotomy with both venæ cavæ being occluded while the heart is being operated on High frequency currents are used to restore the temperature One successful case is reported by Floyd Lewis who operated on a five year old child The freezing process took two hours the operation included the heart being opened for over five minutes Forty minutes were required for the warming process

This work which owes much to the original experiments of Bigelow is being elaborated as a result of animal operations Cookson Neptune and Bailey (1952) suggest that depression of the body temperature in man to 26° C might allow both venæ cavæ to be safely obstructed for a period of nine minutes during which the heart could be incised and a dry field of operation be obtained Bailey has used this method in transposing the aorta and pulmonary artery in a case of transposition of the great vessels

Delorme (1952) has worked on cooling blood as it passes through a length of special tubing which connects the femoral artery and vein The simplicity and efficiency of this method have much to commend it though it has been difficult to avoid occasional ventricular fibrillation

blood passes through the oxygenator and is pumped back into arterial catheters which are passed *via* the subclavian or femoral arteries into the aorta. The incision and exposure demand most careful hæmostasis because of heparin. The heart is then incised and a practically dry chamber encountered though one obtruding

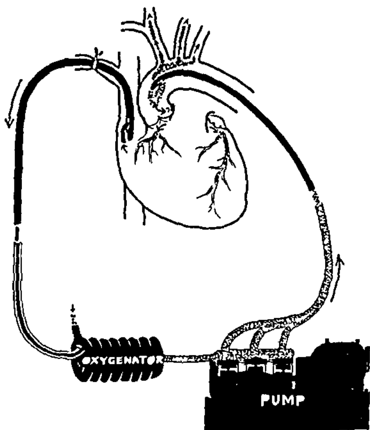


FIG 96 Heart lung pump Blood is sucked out of the right atrium through a catheter and passed through the oxygenating system before being pumped back into the aortic arch From this site if the pressure is satisfactory an adequate cerebral and coronary blood supply is maintained Clotting is prevented by the preliminary use of heparin

factor will always be the coronary venous return which amounts to the considerable figure of 300 ml per minute This blood can be collected and returned to the artificial heart When the heart has been closed it is allowed to take over its own pumping action as the machine is put out of circuit The action of heparin is countered by protamine sulphate and the blood pressure maintained by adrenaline preparations Ventricular fibrillation if it occurs can be countered

prevention is better than cure The most striking feature about cardiac invalidism is that children who have been regarded as serious heart cases with restricted activity for many years will undergo the operation and in a space of a month or so take up normal activities and forget that there has ever been anything wrong with the heart

Treatment The ductus itself is a short channel, usually about 1 cm in diameter and 1 0 to 1 5 cm long Occasionally it is so short that the aorta and pulmonary artery are in close contact The operation consists in occluding the ductus either by ligature, which suffices in the majority of cases, or by division with suture of the cut ends Though many surgeons are content with multiple ligatures ✓Cross (1951) has advocated the routine division of the ductus This is achieved by exposing the ductus thoroughly, reflecting all adventitia and pericardial fringes and then applying four fine

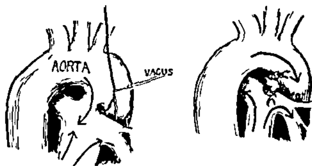


Fig 97 Patent ductus arteriosus—method of securing by double ligature

clamps The vessel is divided between the second and third pairs which are then removed and the exposed edges are secured by arterial sutures The reason for this more complicated and exacting procedure is based on the fear of recanalization which is said to occur in a proportion of cases In the writer s experience though this complication cannot be excluded it is probably much less common than supposed some of the so called recanalizations being due to co existent and unrecognized arterio venous fistulae which result from infective endocarditis The average operation is straight forward and is always more easy in children than adults It is performed through a left postero lateral thoracotomy, and if there are no complications the child is able to leave hospital in twelve to fourteen days

Results Among the series that have been published the figures given by Cross and Longino (1951) may be mentioned In 412 operations there was a mortality of 2 1 per cent , and if the symptom

If hypothermia can be shown to be safe, it would seem to offer a greater future than the more complex extracorporeal methods The problems to be solved are the depth at which hypothermia can be maintained and its duration, so that damage to the more specialized type of body cell can be avoided

CONGENITAL HEART DISEASE

Patent Ductus Arteriosus

In certain individuals the ductus arteriosus remains patent after birth and persists with the result that a certain proportion of the high pressure arterial blood enters the pulmonary system through *this channel Two features follow The pulmonary artery has to* carry more blood than it was designed for and the pulmonary vessels in the lungs are engorged and even show systemic vessel pulsation The left ventricle has to enlarge to overcome the loss of blood through this arterio venous fistula, and if this process continues heart failure will ultimately result The patients are never cyanosed except in terminal stages and the activity of the patient is not unduly restricted so long as the left ventricle can compensate for the shunt

The dangers of the untreated ductus lie in infective endocarditis, heart failure and in the cardiac invalidism that results from the parents and the child realizing that there is something wrong with the heart This last factor is most important since it interferes *with the normal education and social development of the child* During the last few years it is becoming accepted that a patent ductus arteriosus is a surgical condition in which operation is called for unless there are definite contra indications This attitude has been justified by low mortality of the operation which in several large series is only 1 or 2 per cent and the routinely good results that follow The policy of most cardiac surgeons is to consider operating on every child from the age of four and five years upwards if the lesion is causing any physical or functional disability Admittedly patients can live to middle age with a patent ductus and there are instances in which women have borne children in spite of this disability but in general the heart tends to enlarge rapidly between the age of seventeen and twenty and at the same time atheromatous changes develop in the ductus—a feature that makes surgery much more hazardous Infective endocarditis which used to be regarded as one of the strong indications for surgery can often be controlled by antibiotics but here again

The deficient oxygenation in the systemic circuit leads to a compensatory increase in the oxygen carrying vehicle, hæmoglobin with the result that a polycythæmia develops and the red cell count may reach 7 to 10 millions and the hæmoglobin content be raised 50 to 100 per cent /

The lesion is a varied one and ranges from a valvular stenosis in which the valve is converted into a cone with a pin point opening, to all types of narrowing in the infundibular track or main pulmonary arteries In addition there are further complicated lesions, such



FIG 99 Angiocardiography in Fallot s tetrad The injected dye has outlined the great veins and having filled the right auricle has passed into the right ventricle

as truncus arteriosus tricuspid atresia and transposition of the great vessels which give the same clinical picture

Clinically the disease is characterized by intense cyanosis and gross exercise intolerance The majority of children are born blue or become blue shortly after birth this persists through infancy into childhood and if untreated many of these sufferers die before reaching adolescence Survival into young adult life does occur but the patient s ability to lead a normal existence is seriously curtailed The children are blue in the lips tongue ears, cheeks and extremities the eyes are bloodshot and fingers and toes show

less cases only were considered the mortality was as low as 0 5 per cent

Pulmonary Stenosis

Complete pulmonary stenosis prevents the flow of blood to the lungs and is incompatible with life unless there is some by pass or fistula which lets enough blood into the pulmonary system for oxygenation Such an escape can be provided by a patent ductus

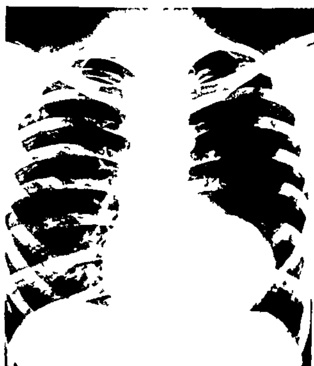


FIG 98 Fallot s tetrad Sabot shaped heart with concavity in the pulmonary conus area Considerable reduction in the vascular markings of the lung fields

arteriosus but when the stenosis is partial there may be a patent interatrial or interventricular septum which relieves the pressure in the right heart

The most commonly recognized form of pulmonary stenosis is the tetralogy or tetrad of Fallot in which there is a patent inter ventricular septum with the aorta overriding this deficiency The cyanosis that characterizes the condition arises from two factors —

1 The imperfect pulmonary circulation due to a narrowing in some part of the pulmonary outflow tract
2 The aorta receiving venous blood direct from the right ventricle

strated clearly that if there is a pulmonary artery big enough to receive the anastomotic channel from the systemic circulation, that portion of systemic blood which will be then deflected into the lungs will become fully oxygenated

The original operation consisted of implanting the right subclavian artery into the side of the right pulmonary artery, and the principle of this anastomotic operation, though now frequently practised on the left, has produced many excellent results It is, admittedly, an indirect operation which adds one more abnormality to the already complicated heart condition but the earlier fears that the opening would narrow or that endocarditis would develop have not

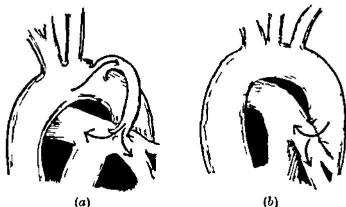


FIG 101 Pulmonary stenosis—anastomotic or indirect operations (a) Blalock type (subclavian into pulmonary artery) (b) Potts side to side junction between aorta and left pulmonary artery

been borne out The tendency at the present time is to operate on the left side where the heart can be exposed and the actual site of stenosis located Then if an anastomotic operation is to be performed the left subclavian and left pulmonary artery can generally be brought together after some of the proximal branches of the subclavian have been divided

An alternative procedure only practicable on the left is Potts modification in which an anastomosis is made between the side of the aorta and the left pulmonary artery ′ This latter operation is made possible by an ingenious clamp which only excludes part of the aortic wall during operation but the size of the opening has to be carefully calculated so as the completed orifice is not more than 4 mm diameter a larger channel may lead to undue left heart strain and even to failure The mortality of these procedures varies between 8 and 12 per cent but in all cases where an efficient anastomosis is performed there is some improvement usually of a remarkable nature

marked drumstick clubbing The heart is not necessarily large and any enlargement occurring is confined to the right ventricle The heart outline takes on a 'sabot' shape with the apex tipped counter clockwise The pulmonary conus is invisible and there is *absence of pulsation of the vessels in the lung fields* On the other hand the original conception of absent or very small pul

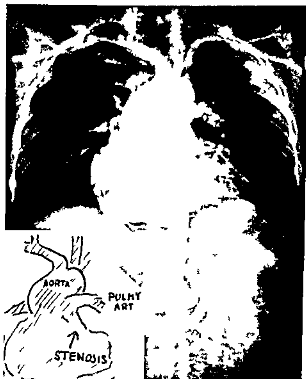


FIG 100 Angiocardiography in Fallot s tetrad The dye has simultaneously outlined the aortic arch and pulmonary artery stems implying a free communication between right and left heart circuits The descending aorta and its branches are filled as well as the branches off the arch of the aorta

monary vessels has not been borne out the vessels may be of normal size and indeed the common pulmonary trunk invariably shows a marked post stenotic dilatation The important feature is that the blood flow in these channels is reduced to a minimum

Angiocardiography is frequently employed to detect the type and nature of the heart lesion and in many cases the actual area of stenosis can be visualized

Treatment The surgical treatment of these patients is based on the brilliant work of Blalock and Helen Taussig (1944) who demon

one Brock has most ably enlarged the scope of the direct operation by resecting the infundibular obstruction by means of a punch introduced through the wall of the ventricle The mechanical advantages of the direct operation are to allow an improved flow into the pulmonary circuit and to prevent a great deal of the deflection into the aorta, but it does not obviate the interventricular defect with the overriding aorta

In the series that Brock (1952) has published using the direct operation the results have been markedly successful His figures of 111 cases with a low mortality point to the considerable possibilities of this procedure Theoretically, the principle of the operation is superior to that of the indirect or anastomotic one, but the risks are probably greater and it is not always easy to assess the internal damage to the heart muscle

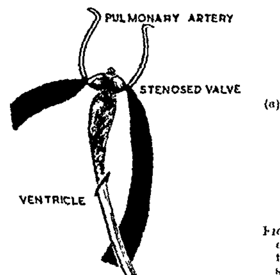
Surgery has undoubtedly been worthwhile in these patients, even though the results are not perfect and the effects may not be permanent Children almost completely incapacitated are frequently able to resume school life and activities, short of playing games Young women have borne children since the operation and the relief to the families is one of the most gratifying features

Coarctation of the Aorta

Coarctation of the aorta which commonly appears as a stricture in the region of the ductus arteriosus was first successfully operated on by Crafoord (1944) and by Gross (1944), the treatment consisting in resecting the narrowed area and performing an end to end anastomosis There has been a modification suggested by Blalock in which the left subclavian artery is turned down and joined to the descending aorta below the coarctation The most common type of coarctation occurs at the site mentioned, but other forms are occasionally encountered in which the stenosis occurs on the arch of the aorta and leads to differences in the blood pressures in the arms The stenosis varies in extent from a sharp short narrowing with a normal sized descending aorta to a much longer form with an atrophic descending artery

The effect of the coarctation is to produce marked signs of hypertension above the constriction with lowered pressure below In other words the blood pressure in the arms will be well above normal, while that in the femoral vessels will be absent or at least greatly reduced it is this latter that is the important diagnostic feature Physical signs produced by hypertension may not become apparent until young adult life when headaches throbbing diffi

A direct attack on the stenosis resulted from the successful division of the pulmonary valve by the writer (1947) and by Brock in 1947. In this procedure the valvular stenosis was divided by incising the wall of the right ventricle and passing a valvotome



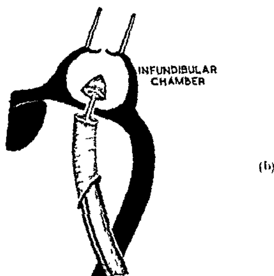


Fig. 102. Pulmonary stenosis—direct operations. (*a*) Valvotomy for imperforate or stenosed valve. (*b*) Punch resection (Brock) of septum in infundibular region.

(By courtesy the Editor, The Practitioner)

upwards to cut through the stenosis. This type of operation is undoubtedly the correct one for all cases of pure pulmonary stenosis and for many cases of Fallot's tetralogy with valvular obstruction. In other cases the obstruction is located in the infundibular region and indeed may be combined with a valvular

and the original stitch used by Crafoord in which the intima was excluded seems to have been abandoned

If a careful choice is made the results of operation are excellent, but if the selection is widened to include patients with symptoms

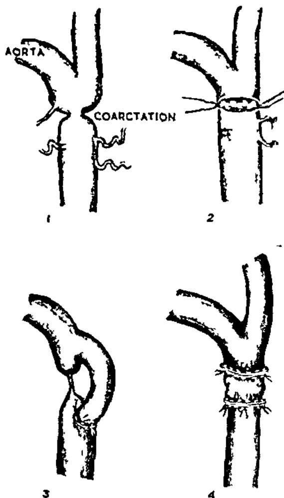


FIG 103 Coarctation of the aorta — methods of treating (2) End to end resection (3) Subclavian artery turned down into the descending aorta (4) Aortic graft

(*By courtesy the Editor The Practitioner*)

or patients approaching their thirtieth year there is a long story of trouble and a number of disasters

Gross (1950) has recorded 100 patients among whom 11 died There were an additional 9 in whom exploration only was undertaken but satisfactory results were achieved in 71 instances Clagett (1951) reported that out of 70 patients with coarctation nothing could be done in 8 The operative mortality in this series was 7 per cent

Abnormality of the Aortic Ring Abnormalities in the formation

culties with vision and giddiness are the predominant features The reason for the hypertension is not only mechanical it is probably due in part to the reduced blood supply to the kidneys over a period of years Renal function however may be normal because a large collateral system will have developed in the inter costal and internal mammary vessels to try and connect the circulation above and below the coarctation

The tortuous and dilated intercostal vessels may produce pressure notching or erosion of the under surfaces of the ribs usually between second and fifth or sixth About the same time as symptoms occur in early adult life the aorta develops atheromatous changes which influence surgery considerably since sutures may not hold in areas so damaged In untreated cases death occurs before middle age from cerebral haemorrhage rupture of the heart or great vessels or some similar catastrophe due to gross hypertension

Treatment Operative treatment consists in excising the coarctation and restoring the continuity of the aorta by direct end to end sutures or graft Many of the original surgical attempts were made on people who had symptoms and it has become apparent that many of these had well marked sclerotic changes in the aorta The difficulties which resulted have led to the view that if operation is to be performed it should be done in early childhood and certainly before eighteen or nineteen years of age In these cases the tissues are soft the divided ends of aorta can be mobilized and the sutures hold well Beyond this age the enormous dilatation of the aorta which brings the subclavian artery practically flush on to the coarctation gives rise to technical difficulties if there is a gap that cannot be easily bridged One method for dealing with a wide gap has been introduced by Gross (1951) who uses a human aortic graft and this allows restoration of continuity without tension In a series of nineteen operations there were two deaths The ultimate fate of the graft is not determined but it has held successfully for at least three years The use of grafts has increased the scope of treatment since the junction can be effected without tension and is applicable to older patients

The operation consists of a wide left thoracotomy a procedure that is extremely bloody owing to the dilated and tortuous arteries, and then a prolonged and detailed dissection of the coarctation and the aorta either side of it One or more intercostal arteries may have to be divided Clamps are applied to the aorta while the coarctation is resected and an end to end junction using an everting stitch is made between the cut ends A continuous suture inter rupted six or seven times during the anastomosis is usually effective

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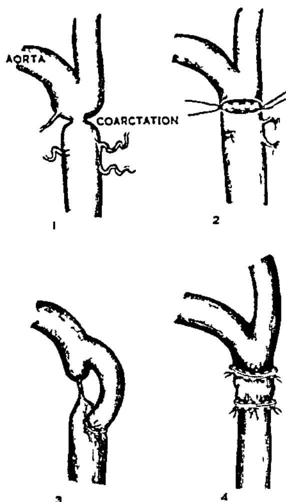


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with loss of heart sounds and a radiologically "still" heart with rapidly failing circulation suggests urgent operation An incision to the left of the mid line with excision of a short length of one of the lower costal cartilages reveals the tense bulging and purple sac This is incised and the blood gushes forth and the wound in the heart is then exposed controlled by digital pressure and sutured

If the circumstances are not so urgent, or if the patient has survived the initial injury by some hours aspiration of the pericardium can be undertaken and repeated as often as required This treatment is based on the assumption that the wound in the heart if not rapidly lethal will seal itself off

Published experience with heart wounds does not only refer to war injuries but to civil practice where Bigger (1939) collected 141 cases largely from the Southern States of the U S A

Subacute Tamponade Subacute tamponade due to excessive pericardial fluid usually results from a tuberculous effusion, some times on its own or sometimes as part of a polyserositis With gradual cardiac compression the pulse volume is reduced and on the slightest exertion there is marked tachycardia, at the same time the inability of the heart to relax fully produces a steadily rising venous pressure Repeated aspiration is usually sufficient to check the immediate effects of pressure but the site for aspiration is not always made sufficiently clear Aspiration anteriorly in the inter costal spaces may well puncture the pleura and even lung and the proximity of the descending branch of the left coronary artery on the heart surface should be borne in mind every time the sharp needle point is lying within the pericardium The presence of the internal mammary artery close to the sternum is another source of danger The correct site though it is technically more difficult is between the xiphisternum and left costal margin passing the needle obliquely upwards through the muscles but outside the peritoneum to reach the diaphragm Here the thickness of this muscle can be felt and the needle will enter the pericardium in a safe region The angle of the needle with the abdominal wall is about 20 degrees and if the operation is likely to be repeated the site of a successful aspiration and depth should be carefully recorded

Constrictive Pericarditis ✓

Chronic compression of the heart is exemplified by constrictive pericarditis which almost invariably is the end result of a tuber culous infection of the pericardium Rheumatic fever never produces this condition and though it may arise as a result of

of the aorta and great vessels though not common are of varied character The aortic arch may be duplicated, there may be a right sided aortic arch with a left ligamentum arteriosum, the innominate artery may be anomalous with branches crossing to the opposite side and the common carotid and subclavian can take unusual courses These abnormalities are not important unless they cause pressure and they only produce clinical signs and symptoms if they compress or distort the œsophagus and trachea Frequently the double aorta or anomalous vessel passes in such a way that this pressure occurs Gross and Neuhauser (1951) have described forty examples of this type of lesion

Symptoms may occur in early life or may only develop as years go by Asthmatic attacks or difficulty in swallowing are common features and radiological and endoscopic investigations may reveal a "soft stricture" or an indentation

Treatment is only necessary if the symptoms are severe Some children lose their symptoms as they grow older, but others require attention in view of threatened asphyxia or dysphagia Angiocardiography may give valuable information as to the side for approaching the mediastinum When the obstruction has been defined the origin and course of the vessels must be determined Before the constricting artery is divided it should be temporarily clamped to see if there is an adequate carotid supply usually the smaller limb can be severed in the case of a double aortic arch, but the carotid and subclavian vessels may have an anomalous course

ACQUIRED HEART DISEASE

Cardiac Compression

Acute Tamponade Acute cardiac compression is most commonly seen with penetrating wounds of the heart If the flowing blood cannot escape from the pericardium this increasing and enclosed mass hinders the output of the heart The blood pressure falls and the pulse rate rises until the heart is brought to a standstill or the hæmorrhage ceases This only applies if the pericardium is intact because if the sac is torn the escaping blood passes into the pleural cavity and the signs are those of concealed internal hæmorrhage and not of cardiac compression Fluoroscopy provides a most valuable diagnostic aid a case with tamponade showing an enlarged rounded and complete immobile heart shadow

Treatment usually depends on the speed with which surgery can be made available to the patient A stab wound in the pericardium

even absent The original description of a small quiet heart is not always accurate since the thickened pericardium may add to the overall diameter of the heart shadow, the loss of movement is the essential feature

Treatment Medical treatment can do much to stabilize the ill patient, but can do nothing towards permanent cure, which must remain a surgical problem In the early stages of pericardial involvement chemotherapy notably streptomycin has been held to hasten the process of resolution and to allow earlier operation than would have otherwise been the case The writer has however failed to find any benefit from this form of treatment Churchill (1936) and others including the writer, have always felt that the essential defect was failure of the ventricular diastole, a feature described by Richard Lower 300 years ago The theory that the constriction was based on narrowing of the venæ cavæ was recently advocated again by Holman (1951) whose work has attracted considerable attention Against this conception of venous obstruction a number of catheter and angiocardiographic studies have been carried out in which it has been shown that the pressure in both venæ cavæ atrium and hepatic veins is the same and that the opaque solution shows no obstruction in the course of the great veins If the theory of failure of ventricular diastole is accepted then the operation must primarily aim at freeing the ventricles Ideally the whole heart should be freed but this is impracticable at one operation once away from the surface of the ventricles dissection of a firmly adherent pericardium can become a hazardous undertaking over the thin walls of the atria and great veins

Earlier operations which aimed at an extrapleural exposure have largely given place to a formal left transpleural approach Through the anterior or posterior incision the pericardium is exposed after the lung has been allowed to retract and the white thickened membrane of the fused pericardial layers is cautiously incised until the level of the actual heart muscle is reached This covering is removed over as wide an area as possible taking care to avoid coronary vessels It is not always practicable to find the correct layer at the first incision and frequently only the parietal layer is excised thinking that the whole pericardium has been removed No operation is complete if the visceral layer stays behind

Pericardiectomy even if only performed over a small area can give considerable improvement but whereas there is no evidence that the heart muscle itself is diseased the greatest care has to be exercised during the operation since the heart tends to irregularities and sudden arrest Holman (1951) advocates exposing the heart by

multiple secondary deposits and other rare causes the majority of cases will ultimately reveal evidence of tuberculous origin

Three types of constriction can be defined —

1 The disease starts as a pericarditis with effusion and as the effusion thickens the parietal and visceral layers of the pericardium become adherent Then the vigorous and unrelenting contraction of tuberculous scar tissue in the course of time completes the constriction round the heart

2 This type originates as part of a polyserositis with all the serous cavities being involved The pericardial involvement is only one factor in the disease process but in time, if the patient does not die from disseminated tuberculosis, pericardial constriction dominates the picture ✓

3 This group of patients covers those in which the onset of the condition is not recognized and the patient presents the established clinical features of constriction with symptoms that have been present for months or years Calcification is common in these cases and they are usually diagnosed in middle age and may show cardiac irregularities The term stone heart is not inaptly applied to cases in which the calcification is gross

Andrews Pickering and Sellors (1948) analyzed a series of 37 patients with constrictive pericarditis and of these 4 were shown to have originated in acute tuberculous pericarditis 16 followed a tuberculous polyserositis and 11 presented with the established syndrome Malignant metastasis accounted for the remainder The writers could find no evidence that suppurative pericarditis led to constriction

The clinical features are traditionally divided into three groups —

1 Above the heart the raised venous pressure is observed in the engorged jugular veins which are distended above the normal limits in the neck and associated with slight facial œdema and congestion of the arms

2 Below the level of the heart ascites and enlargement of the liver are the predominant features œdema of the legs being less common particularly if the patient has been in bed In the past many mistaken diagnoses have arisen the ascites being attributed to cirrhosis of the liver but since clinicians have become more aware of the frequency of constrictive pericarditis these errors are now less frequent

3 The final feature concerns the heart itself and though heart sounds may be heard and its beating felt, fluoroscopy and kymography will show that its movement is greatly reduced or

do not function as rigid flaps but loose billowing structures which squeeze together on closing. The chordæ tendineæ are in two fan shaped groups arising from the papillary muscles and being attached to the margins of the valve cusps. These may be involved in the rheumatic disease process and become shortened, distorted and even fused while the valve edges become adherent and firmly organized round the margins of the stenotic opening. Calcification may also occur. The orifice as found at operation is remarkably constant in size about 1 0 × 0 5 to 0 75 cm.

Three *types* of stenosis are commonly encountered —

1 The cusps are lightly fused except at the stenotic opening where there is a thickening at the edges corresponding to the attachments of the most direct and prominent chordæ. Involvement and contracture of the chordæ is slight and apart from the thickening the commissures are only lightly adherent and can be split easily.

2 Similar to the first group, but with one commissure (or line of valve fusion) and the chordæ being so heavily thickened and fibrosed that it cannot be divided. This usually occurs round the posterior commissure.

3 The cusps and chordæ are so shortened and contracted that the fused valves are dragged into a funnel shape or "fish mouth" opening which cannot be improved by any mechanical procedure except dilatation. Splitting of the commissures is impracticable and in any case the valve would not move as the chordæ are so shortened.

Brock (1952) in an important communication has described the valve orifice as being divided into a flat central blood channel and two more oblique supporting parts. The most important points of attachment of the chordæ are regarded as being the primary points of fusion in some cases and are significant in producing a small and constant size of opening if stenosis occurs.

The aim of the operation is to split or divide the fused cusps along the lines of the commissures and if the chordæ are undamaged some approach to normal valve action may be achieved. The anterior or aortic cusp must not be injured since this guards the mitral orifice from reflux during ventricular systole. Should mitral stenosis be converted into a gross regurgitation the condition of the patient may be made worse than before the operation.

Hæmodynamics Many investigations have been carried out to study the hæmodynamics of mitral stenosis. In simple terms the stenosed valve prevents the onflow of an adequate volume of blood into the left ventricle. The output is therefore below normal and

splitting the sternum longitudinally and avoiding entering the pleural cavities. This approach gives a good exposure to the right atrium and venae cavae. Pockets of caseous material and calcification may add considerably to the difficulties.

The results of pericardiectomy are gratifying. The operation mortality due largely to cardiac arrest during the induction of anaesthesia is appreciable but the survivors show a reduced venous pressure and are capable of considerable physical activities. Cardiac irregularities tend to persist but recurrence of the constriction is unknown though an incomplete initial operation can be improved by a further pericardial excision using another approach.

There are no clear views as to the timing of operation. The pericardium if excised eighteen months to two years after the onset of pericarditis usually comes away clearly from the heart muscle but if the operation is performed earlier there is some uncertainty as to the facility with which the visceral layer can be removed.

Mitral Stenosis ✓

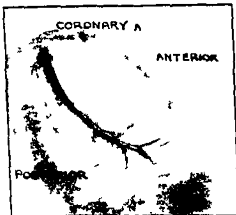
Fifty years ago Lauder Brunton suggested that the narrowed mitral orifice might be relieved by direct surgery but it was not until twenty five years later that Souttar successfully operated on a patient. The view that the rheumatic affection of the myocardium was more important than the mechanical obstruction unfortunately precluded further progress until the last few years when Bailey and Harken in the United States and Brock in Great Britain showed that surgical treatment was possible.

In addition to a direct attack on the valve, a venous anastomotic procedure has been carried out with some success particularly in cases with repeated attacks of pulmonary oedema. The operation consists in joining a branch of the pulmonary vein (the upper branch of the inferior pulmonary vein) to the azygos vein. The blood from the congested lung escapes into the systemic vein and relieves some of the pressure in the pulmonary circuit. The anastomosis in these cases does not always remain patent and the value of this operation has been overshadowed by the greater success of valvotomy. Sweet and Bland (1949) have had some success and d'Allaines (1951) recorded the variable fortunes in sixteen patients.

The direct operation in mitral stenosis consists of an approach through the left atrial appendix which is opened to admit the finger or some instrument with which the narrowed valve is split open. The anatomy of the valve shows that there is a larger and antero medial leaf and a smaller postero lateral one. The valves



mitral valve



Medial

Closed

or aortic cusp balloons into the ventricle like a sail as the valve opens are held in check by the papillary muscles and chordæ tendineæ which

NEWLAND

Normal

Lateral



Open

FIG 104 Opening and closure of the mitral valve The large anterior On ventricular systole the cusps return and squeeze together they are attached at the free edges

other valves are unaffected Damage to the heart muscle should be minimal The patient should be young should have a small heart with normal rhythm should be free of evidence of thrombosis and embolism and above all should have a long interval between rheumatic activity and the time of operation Nocturnal dyspnœa and other evidence of pulmonary hypertension are positive indications for operation when added to progressive disability and loss of exercise tolerance It is difficult to fulfil these criteria and the patient selected is usually one between the age of twenty to fifty years with emphasis on the thirty to forty year group the heart is often enlarged and of an irregular rhythm and a history of pulmonary or cerebral embolism are among the direct indications for valvotomy Most patients operated on have had attacks of pulmonary œdema and many suffer from recurrent hæmoptyses

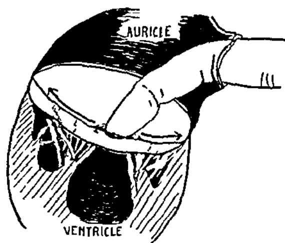


FIG 105 Mitral valvotomy Diagrammatic representation of valves to show arrangements of chordæ to the valve cusp edges On right method of performing valvotomy with the finger

The average case submitted for assessment may seem unsuitable on first sight but after a prolonged period of bed rest and medical treatment with a low salt diet and digitalis when necessary, the tendency to congestive heart failure is diminished and a severely disabled patient may finally become a reasonable subject for operation

Operative Treatment The operation consists in a left thoracotomy The pericardium is then freely opened to reveal an enlarged left atrial appendix The pulmonary artery is much bigger and more tense than normal as also are the pulmonary veins If there is no clot in the appendix a clamp is applied to its base and the tip or side is incised so as to permit entry of the right index finger the use of control sutures being optional The finger is then passed into the atrium as the clamp is released the edges of the incision fitting firmly enough round the finger to prevent blood loss

the aorta remains small which is consistent with the thin and rather underdeveloped condition of the patient Behind the stenosis there is an enlarged and sometimes enormous atrium from which the *pressure is referred back on to the pulmonary veins and thence* through the capillary bed to the pulmonary arteries and right ventricle The pressure in the pulmonary artery steadily rises as the disease progresses and hypertrophy of the right ventricle results This pulmonary hypertension is exaggerated on exercise and may reach a figure of over 100 mm Hg If this persists for any length of time, secondary changes will develop in the small vessels of the lung and lead to permanent pulmonary hypertension Sudden peaks of pulmonary hypertension associated with inability of the veins and left auricle to carry off the blood flow contribute to attacks of pulmonary œdema progressive enlargement of the right ventricle will ultimately lead to congestive heart failure

Catheter studies play a considerable part in assessing the severity of the disorder the tip of the catheter measuring the pressure within the right ventricle pulmonary artery and pulmonary capillary bed The presence of unduly raised figures confirms the severity of the stenosis and the necessity for operation, but there is no guarantee that satisfactory valvotomy will lower the pulmonary pressure to its normal level In any case the post operative readings should not be taken for at least six months after valvotomy Even then it may be found that in some cases the figures will have fallen appreciably *while in others where the clinical result is good there* has been little lowering in the pulmonary artery pressure Indeed one of the remarkable features is the unpredictable effect of valvotomy sometimes a slight enlargement of the orifice gives a good clinical result whereas in others where the valve action is almost reconstituted the effect is far less dramatic Surgeons operating on these patients have noted a remarkable constancy in the size of the stenotic opening As has been stated it measures about 1 0 by 0 5 cm and this would appear to be the critical size compatible with life If a slight increase is made in the size of the orifice it may temporarily allow an adequate blood flow or such an improved flow that relieves many symptoms Ideally a full sized opening with mobile valve flaps should be aimed at but this is not always possible and the surgeon who is dissatisfied with the mechanical side of the valvotomy may be pleasantly surprised with *the clinical result*

Selection The selection of patients suitable for this operation is far from easy The operation ideally should be performed on patients in whom the mitral stenosis is the dominant factor and

other valves are unaffected Damage to the heart muscle should be minimal The patient should be young should have a small heart with normal rhythm, should be free of evidence of thrombosis and embolism and above all should have a long interval between rheumatic activity and the time of operation Nocturnal dyspnœa and other evidence of pulmonary hypertension are positive indications for operation when added to progressive disability and loss of exercise tolerance It is difficult to fulfil these criteria and the patient selected is usually one between the age of twenty to fifty years with emphasis on the thirty to forty year group, the heart is often enlarged and of an irregular rhythm, and a history of pulmonary or cerebral embolism are among the direct indications for valvotomy Most patients operated on have had attacks of pulmonary œdema and many suffer from recurrent hæmoptyses

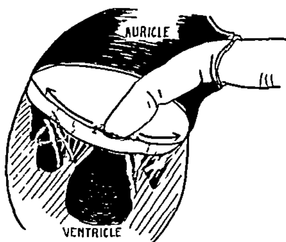


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The finger tip feels for the roughened edges of the stenosed opening and using fairly considerable pressure the commissures are split in a postero medial and an antero lateral direction out to the valve ring If the structures are too tough or firm to be torn a knife like instrument attached to the finger can be used to make a preliminary incision The operation is not one of dilatation but of splitting or tearing avoiding damage to the anterior leaf The finger should not obstruct the blood flow for more than two or three beats at a time On completion the finger is withdrawn as the clamp is reapplied and the incision closed by simple suture

If the atrial appendix is too small to admit the finger or if it is the site of a heavy thrombosis access to the valve may be gained through the dilated pulmonary vein trunk, or even through incision in the atrial wall

The risk of blood loss is obvious should the opening into the thin walled atrium split or tear but it is unusual for a hæmorrhage to be uncontrollable if care is taken The response of the heart to the actual manipulation can be grotesque with periods of arrest tachycardia and ectopic beats but if the handling is gentle and procain is used to reduce myocardial irritability the situation should be easily controlled

The post operative course is usually straightforward so long as the lung is fully and promptly expanded Occasionally ordinary sinus rhythm is converted into auricular fibrillation if there is any pulmonary collapse or access of fluid within the pericardium or pleura Once the obstruction is relieved the patient feels a sense of freedom characterized principally by loss of tightness in the chest and within some days the shortness of breath is obviously relieved and patients may even be able to sleep lying flat

Results The results are gratifying the mortality in the larger published series of cases varies between 6 and 11 per cent It has been noticed that with increased experience and selection the mortality tends to fall Logan and Turner (1953) report 100 cases with an operative mortality of 7 per cent and with good results in more than two thirds Baker Brock and Campbell (1952) with an experience of 100 patients describe carefully the indications and selection of patients There were 13 deaths shortly after operation, and in a follow up of 50 patients the results six months after valvotomy showed 33 very satisfactory results with less good function on 9 occasions The writer in 125 operations has had 4 deaths and good early results in many cases

Cerebral embolism is the biggest cause of disaster apart from an occasional catastrophe on the operating table This complication

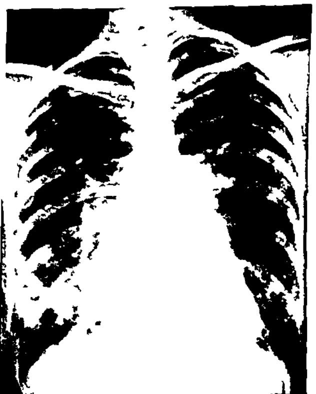


FIG 106 Mitral stenosis before and after valvotomy The typical mitral shaped heart is accompanied by marked *congestion of the* lung fields

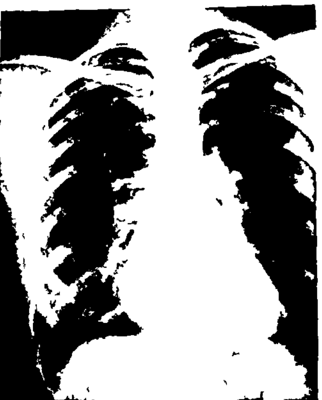


FIG 107 Mitral *stenosis* before and after valvotomy After operation the lung fields are clear

is regarded as so serious by Bailey and others that they temporarily occlude the innominate and left common carotid arteries during the intracardiac manipulation, so that any dislodged embolus will not have access to the brain A torn anterior cusp will lead to severe regurgitation, which cannot be compensated

The symptomatic relief in a successful case is dramatic and bed ridden patients can become ambulatory within a week or two The average disabled case who could only just walk about slowly is often able to return to housework shopping or a reasonable degree of activity and the question of recurrence of the stenosis, though not answered finally would appear to depend on the quiescence of the rheumatic process Experimental evidence suggests that any raw surface within the heart will become rapidly endothelialized possibly within two or three days if the valve flaps are moving freely and do not show raw surfaces it would seem that the chance of their secondary adherence is small but this is a point that time alone will determine

The psychological or functional element in mitral disease is important Unnecessary invalidism is common and an operation even though not successful may give improvement which cannot entirely be attributed to the mechanical benefit Preliminary medical treatment and the psychological relief may have played a large part in the good result of some operations *Per contra* a good mechanical result may not be associated with the degree of progress expected if the patient cannot relieve herself from cardiac invalidism

One important aspect of mitral disease is the volume of work that may result if the early successes of valvotomy are maintained Paul Wood has estimated that within the age group of twenty to forty there are 150 000 cases in this country of rheumatic heart disease with mitral stenosis as a prominent feature and he suggests that possibly half these will require valvotomy sooner or later This estimate may be on the high side but it is a factor which needs consideration

Mitral regurgitation has been treated by threading a length of living tissue loosely across the deficiency so that the strip sags into the ventricle during auricular systole but obstructs it when the ventricle contracts If the graft can be hooked or sewn to the edge of the anterior cusp it can be used to tighten the valve and reduce the opening Gordon Murray (1950) has used a vein turned inside out threaded over the palmaris longus tendon and Bailey (1951) uses a pedicled tube of pericardium sutured so that the serous edges are outwards He reports 7 cases with improvement in all but 1

The strip is passed into one side of the auricle and out the other with a finger introduced through the appendix guiding the passage through the left auricle. Logan (1952) has recently recorded 11 cases with good results in most cases. Brock's view in regarding regurgitation as a severe form of destructive valvitis suggests that mitral incompetence which is producing symptoms apart from any co-existent stenosis may be very difficult to treat.

Aortic incompetence is treated on the same principle as above, a loose strip being threaded through the aortic wall well above the valve. A preliminary report has recently been made concerning the insertion of a plastic non-return valve into the aorta above the defective valve with a gratifying early result.

Aortic stenosis affords a more difficult problem than mitral stenosis because of the anatomy of the aortic valve and its pathological distortion. Bailey (1952) showed how the valve can be incised and dilated by instruments introduced through the left ventricle and also used a retrograde method in which a dilator is passed downwards through the right common carotid or right subclavian artery into the ascending aorta and thence to the stenosis. These operations are not without danger, and if the valve ring is disrupted the coronary vessel supply may be jeopardized, and at the same time incompetence results. Dilatation or incision of the anterior cusp would seem to be the safest procedure. Brock (1950) has approached the valve through a cardioscope introduced from above. Some of the results can be regarded as satisfactory, but the pathological changes in the valve make the possibilities of surgery much smaller than with mitral stenosis.

Patent interatrial defects have been closed by invaginating the atrial appendix into the auricle itself and securing it to the edges of the septum by sutures. This is only practicable if the opening has a lower edge, but again following the principle of mitral surgery a finger introduced into the auricle assists the manipulation considerably. A well consisting of a rubber funnel sutured to the opened atrial appendix has been used by *Gross (1952)*. *The depth* of the well prevents the blood from escaping and the surgical manipulations are carried out by finger and instrument *through the* funnel. Plastic plates or sheets have been sutured into the *defect* to help in its closure.

Patent interventricular defects have been *treated by* [illegible] Murray (1948) by threading *strips of fascia lata on blunt* [illegible] across the ventricle walls. *The procedure could not be* [illegible] lesion was complicated *by other defects as occur in* [illegible] tetralogy, and on the whole the *future of operations* [illegible]

may have to await developments of heart lung machines or hypothermia

Myocardial Ischæmia

Coronary artery disease remains one of the greatest challenges to medical science In England and Wales the Registrar General's Report gives a figure of 36 640 deaths due to this cause in 1948 The figure was 15 409 in 1938 The diminishing blood supply ultimately leads to death of the heart muscle, and the life of the patient largely *depends on the extent of this infarction* Moreover, there is the probability that in the course of time further damage will follow and kill the patient

Beck (1943) has introduced the idea of a "trigger" mechanism by which a small amount of ischæmia added to a muscle already *deprived of its full blood supply precipitates the full disaster of* infarction If *per contra* a small additional blood supply can be provided the tragedy may be postponed and many types of operation have been introduced to try and provide a supplementary blood supply to the myocardium to prevent immediate necrosis or to *reduce the risk of further episodes Grafts applied to the heart* have been used in a variety of forms but the success of these has been limited and attention has turned to trying to convert coronary veins into arterial channels

Myocardial Grafting The original work on grafting was carried out *a number of years ago by Beck (1936) and by O Shaughnessy* (1937) the former using muscle and the latter omentum and lung For muscle grafting an anterior approach was used and after the heart surface was exposed intercostal muscle bundles and pectoral muscle was applied to the scarified heart to which they became *adherent O Shaughnessy's omental graft consisted in bringing* omentum into the chest through the diaphragm and applying it to the lateral aspect of the bare heart and whereas the original results seemed satisfactory the operation did not have popular support Recently Mason (1951) has produced results which suggest further *consideration of this method is indicated In a series of 30 opera*tions many results were regarded as giving satisfactory improvement 11 died shortly after intervention but the patients *selected* were regarded as cardiac derelicts

A more simple type of graft comes from use of the parietal pericardium itself Pericardial adhesions are known to bleed freely from the heart end after they are divided and their artificial produc tion has been *advocated by using asbestos powder talc or bone* dust (King 1941) The advantages of this type of procedure is that

the operation is a small and simple one exposing the pericardium through a limited incision and injecting the foreign material Firm adhesions are produced but the functional results are not entirely satisfactory Thompson and Raisbeck (1949) claim that adhesions produced by the introduction of talc powder gave improvement in 70 per cent out of thirty six patients there were six deaths

A more recent innovation is the use of a blood vessel implanted into the heart muscle The internal mammary artery is freed from its branches and the divided distal end is buried for a centimetre or two in the myocardium Vineburg (1951) has carried out this operation on five occasions Experimental work suggests that in this as in other grafting operations, blood vessels bud out from the graft into the heart muscle and provide some additional blood supply

The critics of grafting infer that any new blood vessels only supply a local superficial area and do not penetrate into the deeper layers of the heart muscle which are functionally more important Also in assessing the results of these operations it is difficult to discount the beneficial effects of prolonged medical treatment and rest which are inevitably a preliminary to surgery In spite of a number of successes from all these different methods grafting does not seem to have given a satisfactory answer to the problem

Coronary Vein Operations The left coronary artery is the vessel of supply for the left ventricle which returns about half its flow into the coronary sinus This contrasts with the right coronary vessels whose venous return is largely into the Thebesian system There are also communications with the heart chambers by sinus like spaces and the capillaries connect freely with arteries veins and these spaces It is therefore possible that blood can flow from one part of the coronary system to another On this general basis two surgical procedures have been considered—obstruction of the coronary sinus and arterialization of the coronary veins

If the coronary sinus is ligated the venous return from the myocardium will be obstructed and the vessels engorged The veins and capillaries are dilated and more blood than normal is retained in the heart muscle In this way it is thought possible that potentially ischæmic areas will not be drained so quickly On the other hand Blalock (1950) has pointed out that complete obstruction of the sinus may lead to gross congestion of the deeper layers of the muscle with petechial hæmorrhages in the endocardium As a result experiments aiming at partial obstruction of the venous return have been regarded as more satisfactory Fauteux (1951)

has combined coronary sinus occlusion with periarterial stripping of the main coronary arteries, with the object of combining dilatation with venous congestion He performed this operation seventy eight times with sixteen deaths and good results are claimed in patients between thirty six and fifty two years of age Beck (1951) who has worked for years with the problem has recently devised a complicated and ingenious procedure which aims at partial arterialization of the venous channels An anastomotic channel is constructed between the aorta and the coronary sinus using a free vein graft (taken from the arm) to bridge the short gap between these structures The vein graft is sutured to the side of the aorta with a 4 mm opening and then implanted into the coronary sinus If the force of this shunt is too great for the heart veins to support, the opening on the heart side is reduced at a later operation by

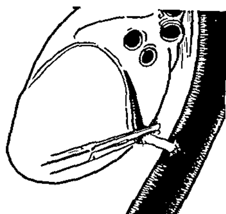


FIG 108 Arterialization of the coronary veins (Beck's operation) A free vein graft is sutured between the descending aorta and the coronary sinus A fine clamp (Pott's type) secures the sinus while the anastomosis is performed

closing the coronary vein to 3 or 4 mm The initial successes of this procedure suggest that it gives as yet the greatest promise of hope in this vast problem

Gordon Murray (1950) has stressed the danger of paradoxical systole of an infarcted area of myocardium The ischaemic muscle is flaccid and when the ventricle contracts this area distends passively causing considerable loss in the ventricular output In experimental animals he used excision and suture of the area to improve this deficiency and more recently Allen (1951) has shown that splinting the infarcted surface improves the cardiac function

Symptomatic Relief The relief of the pain of angina pectoris has received considerable attention and detailed studies of the apparent nerve pathway here led to the supposition that the inferior

cervical and upper five thoracic ganglia are the areas through which pain fibres pass Alcohol injection if accurately placed, gives relief of pain in a proportion of cases but the procedure is not without risk Open operation has considerable advantages, and in expert hands can be safely and accurately performed through an anterior or posterior incision The anterior approach in the base of the neck follows the lines of a phrenic nerve operation but the scalenus anticus muscle is divided to expose the sympathetic chain whose lower ganglia are reached by retraction of the apex of the pleural cavity forwards The posterior approach is a more extensive operation but the lower ganglia are more readily exposed and the anatomy of the sympathetic chain more easily defined In any case the operation must be carried out on both sides but in spite of the claims made for the success of sympathectomy the operation is not widely used

Congestive heart failure has been treated successfully on occasions by ligation of the inferior vena cava It is held that the exclusion of a considerable volume of blood from the right heart reduces the load on the heart and leads to considerable alleviation of symptoms Severe congestion of the lower extremities follows the ligature, but this subsides slowly

The inferior vena cava is approached from an oblique incision in the loin The operation is popular in Latin America, and from France d Allaines and his colleagues (1950) report 39 successes in a series of 55 cases

Aneurysms

Intrathoracic aneurysms have been treated by a variety of methods over a number of years Gordon Taylor (1950) has recorded the collected adventures of surgeons with innominate aneurysm where ligature was the mainstay of treatment Wiring of aortic aneurysm by Colt s method has received impetus from Griffin and Borrie s (1950) figures in which there were good results in 6 cases with one death in nine operations This method is suitable for saccular aneurysms adherent to the chest wall The more elaborate electro coagulation methods of Blakemore (1948) have had some success in promoting clotting within the sac particularly if combined with constriction above and below the aneurysm with polythene tape The use of cellophane strips encircling the aneurysm was advocated by Harrison and Chandy in 1943 This material produces gradual fibrosis but the operation which entails a preliminary freeing of the aneurysm is not without hazard if it is adherent to intrathoracic structures Cellophane wrapping is



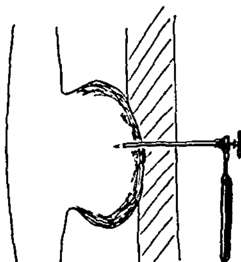
Fig 109 Aortic aneurysm Large and immobile mass arising from the right mediastinum with elevated diaphragm due to phrenic paralysis



Fig 110 Aortic aneurysm Cardioangiography in the oblique view shows the mass to be a saccular aneurysm of the ascending aorta This was treated by injection of Colt s wires

indicated in the case of fusiform aneurysms and the most suitable site is according to Poppe the descending aorta

A more radical and potentially more successful method of treat



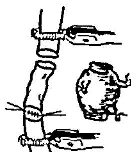


Fig 112 Excision of aneurysm with restoration of continuity with a free arterial graft

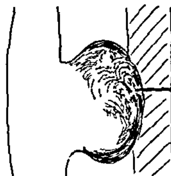


Fig 111 Treatment of saccular aneurysm adherent to the chest wall by Colt s wire umbrella or wisp

Fig 113 Partial excision of a saccular aneurysm and repair by suture

Figs 111–113 Aneurysm

ment may well develop from the use of arterial grafts These are undoubtedly superior to plastic forms of vascular protheses and appear to survive without degeneration they can be stored safely under special conditions in a " deep freeze for twenty five days The area of the aneurysm can be by passed even if the sac is not excised but in most cases it is possible to remove or obliterate the

sac The use of short length grafts in treating coarctation has been established by Gross (1951) and the treatment of aneurysms is an elaboration of this principle involving longer lengths of grafts Lam (1950), Swan (1950) and Brock (1953) have all published successful cases

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PART IV—THE GENITO-URINARY SYSTEM

R H O B ROBINSON

INTRODUCTION

RECENT advances in genito urinary surgery have widened the field of conservative surgery and stressed the importance of early diagnosis Many conditions which in the past led to irreparable damage can now be nipped in the bud Infections of the urinary tract demand thorough investigation which often leads to the discovery of some unsuspected abnormality the correction of which is essential for permanent eradication of the infection The appro priate sulphonamide and antibiotics are bactericidal to all the common infecting organisms although some of them, such as pseudo monas pyocyaneus and bacillus proteus are difficult to destroy

The prognosis in genito urinary tuberculosis has been improved by the use of streptomycin and para aminosalicylic acid as adjuvants to surgery and in certain cases their use has avoided the necessity for surgical interference Isonicotinic hydrazide (isoniazid) has not yet been adequately assessed

The recurrence rate in nephrolithiasis can be lowered by resection of the stone bearing area in the affected kidney, and phosphatic stones can sometimes be dissolved by the use of a buffered citrate solution solution G It is possible that hyaluronidase may prove of value in producing the resolution of stones or preventing their formation

Exact diagnosis of renal lesions has been rendered easier by aortography, which outlines the vascular pattern of the kidney and perirenal oxygen insufflation which gives a clear outline of its exact shape Both these methods can be combined with simul taneous pyelography In some cases the differential diagnosis of tumour and cyst of the kidney can only be arrived at in this way, but both methods should only be used if the diagnosis cannot be arrived at by simpler means

Certain cases of anuria or oliguria will occur in which the correc tion of the chemistry of the blood and the use of dialysis by various methods including the artificial kidney may tide the patient over a critical period Lower nephron nephrosis tends to recovery

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CHAPTER XIX

OPERATIONS ON THE KIDNEY

Position of the Patient It is essential to have a modern type of operating table in order to obtain good access A table which breaks in the middle allowing the legs and the thorax to be lowered, thus opening up the costovertebral angle when the patient is in the lateral position gives better access than is given by a bridge or kidney pillow under the loin Rotation of the trunk is controlled by suitable supports for the pelvis and chest

Surgical Approach to the Kidney In the past several factors have militated against direct and adequate approach to the kidney, in particular the fear of sepsis and the fear of opening the pleura with resultant collapse of the lung Modern anæsthesia and the use of antibiotics when necessary have made these fears negligible At the present time some surgeons have even suggested routine abdomino thoracic approach to the kidney, having been impressed with the value of this approach in the surgery of war This approach excellent as it is, should be reserved however for those cases in which it is essential owing to the large size or abnormal situation of the mass to be removed The classical lumbar approach gives poor access to the upper pole of the kidney and adrenal, particularly on the left side

Approach through the Bed of the Twelfth Rib An incision 5 to 6 inches in length is made over the long axis of the rib having first of all carefully checked its presence and length in an X ray photo graph A previous preliminary pyelogram gives exact information as to its relation to the kidney The incision is carried down to the rib which is resected subperiosteally The lower edge of the pleura can be seen in the postero superior end of the wound and avoided The bed of the rib is incised between the eleventh and twelfth thoracic neurovascular bundles The incision is carried forwards for a short distance through the muscles of the flank The false capsule is now exposed and incised giving direct access to the kidney

Fey's Approach This is somewhat similar, but is made through the bed of the eleventh rib and is more traumatic being virtually a thoraco abdominal approach Fey admits that in many cases

provided the patient can be kept alive until tubular regeneration takes place

Many ingenious operations have been devised to create an alternative urinary reservoir in place of the bladder the problem being to create a reservoir from which there will be no reabsorption of urinary waste products and which will not transmit infecting organisms or back pressure to the kidneys. In cases where the bladder is too small efforts have been made to enlarge it by ileal grafting and where it is too large to reduce it by removing large parts of the fundus Both these conceptions may overlook the fact that the bladder is only of value if its function is unimpaired The treatment of carcinoma of the bladder still constitutes a baffling problem in the correct choice of the methods to be used in any particular case

There is still no agreement on the best method for removing the enlarged prostate although there is much better appreciation of the factors which make for safety and success whatever particular operation is carried out

The use of cortisone can prevent the formation of dense fibrous tissue after operation for urethral stricture and plastic operation may relieve the patient of the necessity for repeated dilatations

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the pleura is unavoidably opened, and this would appear to be undesirable in a routine procedure The incision is an angled one the tip of the eleventh rib forming the apex of the two halves of the incision The costal limb follows the upper border of the eleventh rib The abdominal limb runs downwards and forwards to the iliac crest The external and internal oblique muscles are divided in the line of the incision The eleventh rib is stripped of periosteum and its connection to the diaphragm at its tip is divided The eleventh rib is retracted downwards like a lever and the tenth interspace opened up The incision is completed by dividing the transversus muscle, when the perirenal fatty capsule is in full view

OPERATIONS FOR HYDRONEPHROSIS

It is now generally agreed that in the pelvic type of idiopathic hydronephrosis lower polar vessels are seldom the actual cause of the condition but rather an exaggerating factor of a developmental error shown by abnormal renal pattern or multiple blood vessels The wisdom of division of lower polar vessels is questionable as it leads to atrophy of the part of the kidney which they supply The problem has been neatly solved by H Hamilton Stewart who has elaborated an operation in which the renal vessels are approximated so that the renal pelvis cannot be snared between two vascular bundles

Any operation to relieve obstructive hydronephrosis ideally should avoid opening the urinary tract as it is virtually impossible to open and drain any part of the urinary tract without producing transitory infection Plastic procedures combined with temporary nephrostomy have this defect

Hamilton Stewart's Operation Any of the recognized lumbar incisions may be used The exposure of the kidney is followed by a dissection displaying the aberrant artery and the uretero pelvic junction Usually as a result of this dissection the tense hydro nephrotic sac can be emptied down the ureter by compression but if necessary the sac can be aspirated with a long fine needle intro duced into the pelvis through renal tissue The lower polar vessels (artery and vein) should be freed from the sheet of connective tissue in which they lie so that they can easily be raised to a higher level The testicular or ovarian vein may need division on the left side The pelvis should now be dissected free on its inner aspect from the same sheet of connective tissue as above so that the pelvis now becomes free and is in a suitable condition for plication if this proves necessary later The capsule is reflected from the front of the upper


(a)


(b)

Fig 114 Hydronephrosis Stewart's operation (a) Pre operative pyelogram (b) Post operative pyelogram

and lower poles of the kidney and is left attached at the convex free border The kidney is grasped in both hands and the upper and lower poles are approximated The anterior surfaces of the stripped upper and lower poles are now brought together so that the

kidney resembles a ball in shape 4/0 plain catgut sutures are now placed through the upper and lower poles to be tied later Hardened catgut tape is now threaded along the new convex border of the refashioned kidney, resembling the rim round a wheel The tape must lie quite flat and is fixed with sutures at the front The plain catgut sutures previously inserted are now tied tightly The two pieces of reflected capsule are brought together and sutured

The kidney is maintained in its new position by the hoop of catgut tape the sutures apposing the anterior poles and the over lapping and suturing of the capsule separated from the two poles If necessary the renal pelvis is reduced in size by plication at the front and back by interrupted ten day 6/0 catgut sutures which do not penetrate the lumen No attempt is made to fix the kidney

The results over a period of ten years are good The moulding of the kidney carries the lower polar vessel upwards into close relationship with the main renal artery thus re establishing the anatomical relationships of infancy The pelvis and ureter are not opened at any time and the arterial supply of the kidney is not interfered with (Fig 114)

Anderson s Plastic Operation An anterior incision is used with the patient in the supine position tilted slightly to the opposite side The incision commences at the tip of the twelfth rib posteriorly and is carried forwards obliquely to the outer edge of the rectus sheath The kidney is exposed extraperitoneally The uretero pelvic junction and upper redundant part of the renal pelvis are resected Anatomical relationships are maintained by a silk stay suture in the upper ureter The method of anastomosis employed dispenses with splinting and eliminates the risk of stricture formation at the site of anastomosis A pelvic flap is turned down from the lower part of the pelvis The upper two thirds of the opening thus created in the renal pelvis are closed by a continuous 4/0 plain catgut suture taking all the coats The upper end of the ureter is slit downwards for a distance of 2 5 to 3 cm and its edges are anastomosed to the edges of the aperture in the lower third of the kidney pelvis and to the edges of the pelvic flap by a continuous plain 4/0 catgut suture taking all coats (Fig 115)

The fact that the lower part of the renal pelvis is turned down as a flap ensures that the pelvis is drained at its most dependent part The method also ensures that the new pelvis, which consists of the pelvic flap and the upper slit portion of the ureter drains into a ureter which has scar tissue at only one point of the circumference and which is not encircled by a circumferential scar Subsequent contraction of the anastomotic scar cannot cause stenosis of the

lumen of the ureter at (b) in Fig. 115b and thus interfere with drainage of the pelvis. Stenosis and stricture formation are inevitable if the ureter is cut straight across and anastomosed directly to a small aperture of similar size in the renal pelvis (Fig. 115d).

There is no splinting of the anastomosis by an indwelling catheter which is against all the principles of plastic procedure as it leads

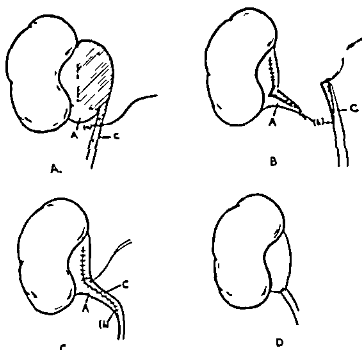


FIG. 115. (a–c) Steps in the operative procedure adopted in this case and in cases of hydronephrosis. (d) A type of anastomosis that will lead to poor drainage and subsequent stricture.
(By courtesy of Mr. J. C. Anderson and the Editor, British Journal of Urology.)

to infection and fibrosis at the line of suture and subsequent stricture. Temporary nephrostomy is unnecessary.

Renal Sympathectomy. This operation is indicated for the relief of pain due to neuromuscular dysfunction of the calyces and renal pelvis or sympatheticotonus as described by S. H. and R. C. S. Harris in 1930 and stressed by Oldham. Hydronephrosis may be well marked on intravenous pyelography and there may be definite delay in emptying of the renal pelvis after retrograde pyelography and yet on exposure of the kidney there may be no evidence of hydronephrosis or mechanical obstruction. The operation is most satisfactory for the relief of pain but its effects on the abolition of the functional hydronephrosis are more doubtful. Sympathectomy must be very thorough as it has been pointed out by Mitchell that

kidney resembles a ball in shape 4/0 plain catgut sutures are now placed through the upper and lower poles to be tied later Hardened catgut tape is now threaded along the new convex border of the refashioned kidney resembling the rim round a wheel The tape must lie quite flat and is fixed with sutures at the front The plain catgut sutures previously inserted are now tied tightly The two pieces of reflected capsule are brought together and sutured

The kidney is maintained in its new position by the hoop of catgut tape the sutures apposing the interior poles and the over lapping and suturing of the capsule separated from the two poles If necessary, the renal pelvis is reduced in size by plication at the front and back by interrupted ten day 6/0 catgut sutures which do not penetrate the lumen No attempt is made to fix the kidney

The results over a period of ten years are good The moulding of the kidney carries the lower polar vessel upwards into close relationship with the main renal artery thus re establishing the anatomical relationships of infancy The pelvis and ureter are not opened at any time and the arterial supply of the kidney is not interfered with (Fig 114)

Anderson's Plastic Operation An anterior incision is used with the patient in the supine position tilted slightly to the opposite side The incision commences at the tip of the twelfth rib posteriorly and is carried forwards obliquely to the outer edge of the rectus sheath The kidney is exposed extraperitoneally The uretero pelvic junction and upper redundant part of the renal pelvis are resected Anatomical relationships are maintained by a silk stay suture in the upper ureter The method of anastomosis employed dispenses with splinting and eliminates the risk of stricture formation at the site of anastomosis A pelvic flap is turned down from the lower part of the pelvis The upper two thirds of the opening thus created in the renal pelvis are closed by a continuous 4/0 plain catgut suture taking all the coats The upper end of the ureter is slit downwards for a distance of 2 5 to 3 cm and its edges are anastomosed to the edges of the aperture in the lower third of the kidney pelvis and to the edges of the pelvic flap by a continuous plain 4/0 catgut suture taking all coats (Fig 115)

The fact that the lower part of the renal pelvis is turned down as a flap ensures that the pelvis is drained at its most dependent part The method also ensures that the new pelvis which consists of the pelvic flap and the upper slit portion of the ureter drains into a ureter which has scar tissue at only one point of the circumference and which is not encircled by a circumferential scar Subsequent contraction of the anastomotic scar cannot cause stenosis of the

stance or by the index fingers of the assistant's clasped hands In the latter case the fingers are so held that they act as a clamp The application of a clamp to the renal pedicle although facilitating the operation may well cause damage to the vessels and in a large series post operative thrombosis may occur in some of the cases

A wedge resection is carried out after the metal or finger clamp has been applied The apex of the V as a rule lies along a line extending across the kidney from the top of the convex lower border of the pelvis This line usually passes at right angles to the long axis of the central portion of the kidney but may vary slightly according to the calyceal anatomy and if one of the middle calyces

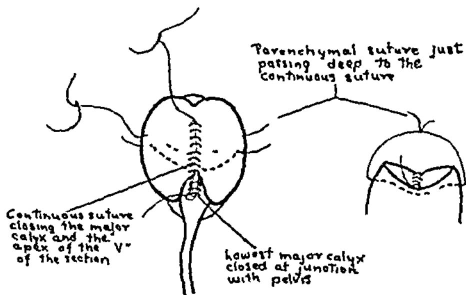


FIG 116 Partial nephrectomy Resection of lower pole
(By courtesy of Mr H H Stewart and the Editor Annals of the Royal College of Surgeons

has also to be included in the resection The aim should be to cut through the lowest major calyx as it joins with the pelvis The kidney flaps should be about 1 inch in length The main vessels are controlled by figure of eight stitches of 4/0 plain catgut The clamp is released from time to time to show the position of the main vessels Stones are removed from the pelvis by an incision carried medially from the opening of the major calyx along the under surface of the pelvis The resected wedge of tissue is examined to see if all the stones shown in the X ray are present If not the renal pelvis and the upper end of the ureter are explored X rays are now taken of the kidney small films being placed in direct contact with the kidney and the absence of stones verified Any clot is removed from the pelvis If an incision has been made in the pelvis, it is

sympathetic filaments enter the kidney over a wide area and not only along the renal artery or arteries There does not appear to be any valid argument for decapsulation at the same time The kidney is exposed freely and all perinephric adhesions divided All the renal vessels are stripped carefully working from the aorta towards the hilum of the kidney The renal pelvis and the upper inch of the ureter are also stripped thoroughly of all connective tissue Oldham has suggested painting the arteries with 10 per cent phenol as an added help At the conclusion nephropexy may be indicated

The operation has the merit alluded to earlier of avoiding opening the urinary tract or draining it temporarily It can of course be combined with a plastic procedure when on exposure of the kidney organic obstruction or a gross hydronephrotic sac are found

PARTIAL NEPHRECTOMY

The introduction of chemotherapy and antibiotics have made conservative surgery of the kidney a practical proposition in cases where the kidney is known to be infected before operation Reactionary and secondary hæmorrhage are always dreaded complications but now with careful surgery seldom occur An individual can maintain health with a third of the normal amount of functioning renal tissue, and therefore thorough eradication of a diseased area of kidney is possible without jeopardizing health

The operation of partial nephrectomy which incidentally does not embrace heminephrectomy for double kidney is indicated particularly in certain cases of calculus disease It has also been advocated by Semb for the treatment of certain cases of renal tuberculosis

Hamilton Stewart has reported on 101 personal cases of partial nephrectomy for renal calculus He points out that the published recurrence rate after operations for renal calculi is from 15 to 30 per cent Extirpation of the diseased calyx usually the lowest in which the stone or stones form should materially reduce this high percentage of recurrences In Stewart's series stones were present in the lowest calyx in 75 per cent The recurrence rate was 6 8 per cent in all cases, infected and non infected The exact localization of calculi is determined by pre operative X ray photographs and if infection is present suitable antibiotic therapy commenced a few hours before operation After free exposure of the kidney and the area to be resected, usually the lower pole hæmostatic control is obtained by the use of a kidney clamp which grips the kidney sub

stance or by the index fingers of the assistant's clasped hands In the latter case the fingers are so held that they act as a clamp The application of a clamp to the renal pedicle although facilitating the operation may well cause damage to the vessels and in a large series post operative thrombosis may occur in some of the cases

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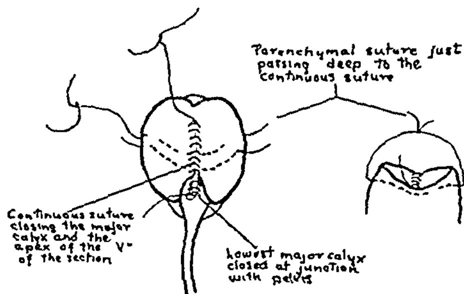


FIG 116 Partial nephrectomy Resection of lower pole
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now closed with a fine continuous stitch of 4/0 plain catgut threaded on a fine round bodied half circle needle The stitch is continued along the apex of the V of the section and the opening of the major calyx thus closed If the pelvis has not been opened the continuous suture is made along the apex of the section only The flaps of kidney tissue are now brought together by 4/0 catgut sutures threaded on a round bodied intestinal half circle needle No 6 These are placed ⅓ inch apart and the same distance from the cut edge The sutures are passed immediately deep to the continuous suture along the apex of the section This procedure ensures obliteration of any dead space at the apex of the section and a good hold for the sutures Great care should be taken to avoid damage to the flaps and the sutures must be carefully placed to avoid interfering with the blood supply The assistant by compression, brings the flaps together and the stitches are tied sufficiently tightly and no more to hold the flaps together Hæmostasis is now complete The capsule must not be closed, it being important that any blood which oozes from the cut surfaces shall escape into the peri renal space and thence to the exterior The kidney is then replaced in the top of the renal space and a bed is made by dissection The kidney is retained in this high position by suturing together the anterior and posterior layers of the renal fascia below it to act as a sling (Fig 116)

A drain is inserted below the closed renal fascia and retained in position for five days A Foley s catheter is inserted into the bladder for twenty four hours to render obvious any hæmorrhage If the urine is still infected appropriate treatment is undertaken to eradicate the infection

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CHAPTER XX

THE BLADDER AND PROSTATE

CARCINOMA OF THE BLADDER

The treatment of carcinoma of the bladder has evolved along lines familiar in other parts of the body but is influenced by two local factors namely the fact that radical surgery demands some alternative disposal of the urine secreted by the kidneys and the fact that bladder tumours are to a varying degree radiosensitive

The published results of radical surgery have proved disappointing, many cases not being diagnosed and subjected to treatment until the disease had penetrated the muscle coats and glandular metastases have occurred Earlier diagnosis is essential and radical surgery is indicated where there are multiple bulky non penetrating tumours and where there are solitary penetrating tumours which have not progressed to the stage of fixation to the walls of the pelvis It must be remembered, as pointed out by Masina, that in many cases of apparently solitary tumour widespread malignant mucosal changes are present in other parts of the bladder

One stage cystectomy and transplantation of the ureters is the operation of choice as it is technically easier to carry out a radical operation for carcinoma in this manner

The bugbear of total cystectomy at the present time now that the immediate operative risks are not excessive thanks to modern anæsthesia blood transfusion and antibiotics, is the remote complication of abnormal renal function Ferris and Odel, in 1950 drew attention to the occurrence of hyperchloræmic acidosis in 80 per cent of patients who have been subjected to bilateral uretero sigmoidostomy

Once the possibility of its onset is realized routine investigation will disclose the changes that have occurred in the blood urea alkali reserve and blood chloride Treatment consists in the administration of alkalies and in a low salt diet Paradoxically, the patient must be encouraged to empty the bowel at frequent intervals to reduce reabsorption from it

In many cases palliative total cystectomy is well worth while undertaking to spare the patient the agonies of repeated strangury and the ill effects of hæmorrhage

It is doubtful whether drastic extirpation of all the pelvic contents and the establishment of a wet colostomy as advocated by Brunschwig is ever justifiable as a treatment for carcinoma of the bladder

The actual technique of the ureterosigmoid anastomosis does not seem to influence the immediate and remote results but whatever technique may be used it is essential to avoid undue stripping of the ureter and undue compression if it is buried in a tunnel in the bowel wall

Alternatively however the results of treatment by radiotherapy are encouraging particularly now that newer techniques are available Intracavitary radiation with isotopes is indicated when surface lesions with little tendency to penetrate the bladder muscle are present Radioactive cobalt is technically easier to apply and offers less risk of contamination than the liquid isotope bromine

Topical treatment by open cystostomy diathermy destruction of the superficial part of the tumour and implantation of its base with radon seeds combined if necessary with transplantation of the ureter into a different part of the bladder has given encouraging results The practical difficulty is to obtain adequate spacing of the seeds and as a result correct dosage Radioactive tantalum wire offers an alternative method which overcomes the risk of uneven radiation

Teleradiation with high power deep X ray avoids the necessity for opening the bladder with inevitable secondary infection and possible persistent fistula With multiple points of entry, ill effects of surface radiation can be avoided and the maximum dose delivered to the tumour

BENIGN ENLARGEMENT OF THE PROSTATE

The treatment of prostatic obstruction due to benign senile changes in the gland still gives rise to controversy and the searcher after truth may be confused by the assurance and conviction of the advocates of widely differing methods

Certain basic principles are agreed and no one method of treatment can ever overcome all the hazards and difficulties or be equally applicable in every case

In the first place the operation must have a mortality because we are dealing with an age group in which there is an appreciable natural mortality apart from any incidental operative interference Further a hard core of derelicts in whom renal damage has progressed to such an extent as to make recovery impossible will always remain Therefore such mortality figures as those of Gershom Thompson,

Wells and Millin are very creditable and approaching the attainable limit. Obviously the proportion of bad risk cases in various clinics differs considerably and must influence mortality figures quite apart from the skill of individual surgeons.

The ideals to be aimed at in any operation on the benign prostate are as follows:

(a) All adenomatous tissue should be removed without damage or removal of any normal prostatic tissue. The suprapubic approach is the best in this respect but any of the recognized methods carefully carried out are satisfactory.

(b) The adenomatous tissue should be removed without dividing or damaging any other tissue during the exposure of the gland. Only the transurethral approach can fulfil this particular condition and the hazard to be avoided is damage to the urethra by excessive dilatation and prolonged manipulation.

(c) The bladder should not be opened or disturbed, and again the transurethral approach is the ideal but the retropubic and perineal approach also fulfil this requirement. Suprapubic prostatectomy with immediate closure does not and may be followed by leakage and temporary interference with bladder function.

(d) The limits of the prostatic cavity should be preserved although it is surprising what liberties can be taken and yet lead to a good functional result. The retropubic approach had the disadvantage of destroying temporarily the very dense layer in front of the prostate which binds the bladder to the pelvic floor and affords the fixed point against which enucleation of the prostate is begun in the suprapubic approach. The only appreciable false capsule of the prostate is this dense layer on the anterior surface of the gland and it is composed of the capsule reinforced by the puboprostatic ligaments and the anterior fibres of the levatores ani. This fact is not as well appreciated as it should be nor is the fact that the capsule at the sides and posteriorly is of nothing like the same strength. The two layers of the fascia of Denonvilliers situated posteriorly and so important in perineal prostatectomy, are thin and afford little support.

(e) The urethra should be preserved inviolate. Over dilatation rough manipulation and infection must be avoided. The distal portion of the urethra is known to harbour organisms in increasing frequency as the meatus is approached and therefore Wilson Hey's insistence on the avoidance of all instrumentation and the downward passage of the drainage tube from the bladder to the exterior is ideal. In fact, if proper methods of catheter drainage are carried out, this point is not of great practical significance.

(*f*) Primary hæmorrhage should be controlled absolutely This factor is the major problem of prostatic surgery as from it stem a formidable array of disasters The most important are clot retention with reflex renal failure profound circulatory changes with renal failure and the much increased risk of superadded sepsis Difficulty in control of the primary hæmorrhage arises from difficulty of access to and visualization of the bleeding points The situation is not so serious if the blood can escape without entering the bladder and producing clot retention The retropubic approach gives the most definite control of bleeding during the course of the operation and any extravasated blood tends to escape by the extravesical drain

(*g*) Early ambulation is highly desirable Old men do not react well to confinement in bed Closed prostatectomy is the object to be aimed at and the transurethral approach is the least incapacitating

(*h*) Infection should be avoided It is true that in some cases the bladder is infected already but in the majority the operation should be an exercise in aseptic surgery and post operative infection due to inadequate management of catheters and mechanisms of drainage should be prevented

Transurethral Prostatectomy

The writer has no doubt that this operation if carried out with the cold punch is the best The procedure has been brought to a high level of efficiency by Gershom Thompson and his followers and one wonders why it is not used more generally The probable reason is that the technique is an exacting one to acquire requires a high degree of team work and close supervision and is impracticable in many cases because of local difficulties of administration

It is impossible in this work to give a detailed description of the operation but at the present time Thompson emphasizes the following points in technique The 27F punch should be used and seldom if ever the 30F This avoids overstretching the urethra with resultant urethral stricture Any narrowing of the urethra assessed by pre operative calibration can be corrected by internal urethrotomy in preference to the alternative method of introducing the punch through a perineal urethrostomy in the bulbous urethra In order to obtain accurate visualization with the smaller instrument he has replaced the plain glass window at the end of the instrument with a 2 5 dioptre lens The operation is carried out under spinal anæsthesia with careful control of the blood pressure Thompson uses water as the irrigating fluid and has not found it necessary to use glycine or glucose to avoid appreciable hæmolysis with the risk

of the crush syndrome kidney. Continuous post-operative irrigation of the bladder through a two-way Foley catheter is used. Foley catheters with various lengths of nose are desirable. Extreme care is taken not to resect at the absolute 12 o'clock position at which point prostatic tissue is negligible and the prostatic plexus of veins and periprostatic cellular tissues are easily opened. Hæmorrhage which is extremely difficult to control may result from this error and extravasation of blood and urine occur. Hamilton Stewart makes a point of introducing a small drain in the cave of Retzius to guard against this eventuality. The lower portions of the lateral lobes of the prostate are pushed into the field of operation by an assistant's finger introduced into the rectum during the concluding phases. The outflow tap of the punch is attached to continuous suction to provide efficient emptying from the bladder of clots and pieces of resected prostate, thus doing away with the need for an evacuating syringe.

The cold punch operation is in effect a variety of prostatectomy and not merely a palliative, for the object is removal of all adenomatous tissue by cutting with a tubular knife, individual bleeding points being controlled by diathermy coagulation. Resection operations carried out with an electro-resectoscope are seldom removals of the prostate in the same sense and it is not accurate to consider them as alternative methods of performing the same operation. Obviously the larger the adenomatous mass to be removed the more difficult the operation becomes in the sense that time is a limiting factor. All the adenomatous tissue must be removed and the operation must not extend beyond an hour. It is for this reason that most surgeons have to adopt other forms of prostatectomy when dealing with the grosser examples of prostatic enlargement.

Retropubic Prostatectomy

This was introduced by Millin in 1945 as he felt dissatisfied with the results of electro-resection and various types of suprapubic operation.

The advantages of the operation are that it is a closed operation and the bladder as a functioning unit is not interfered with in any way. Visualization of the operation site compares favourably with that obtained in other operations. Control of primary hæmorrhage is more definite and removal of the adenomatous tissue can be assured. For obstructive lesions of small size it is not ideal, and it is not always easy to define the correct layer in enucleating adenomata. Should the operation be complicated by sepsis, either pre-

or post operative considerable time may elapse before this can be eradicated finally as the prostatic cavity resulting from the operation takes a long time to heal

Technique Preliminary cystoscopy is essential to establish the exact extent of the enlargement and to exclude any associated lesion in the bladder A transverse incision 4 inches in length is made in the skin crease 1 inch above the upper border of the symphysis pubis The rectus sheath is divided in the line of the incision and two aponeurotic flaps are dissected one upwards for 1½ inches and one down to the upper limit of the symphysis This dissection exposes the rectus muscles and the pyramidales if present These are separated in the midline The transversalis fascia is divided in front of the lower part of the bladder and the peritoneum is pushed upwards exposing the bladder Millin s self retaining retractor is placed in the wound to separate the muscles while the third blade depresses the empty bladder and renders the bladder neck tense Two gauze packs are placed in the lateral recess on each side of the prostatic capsule defining it accurately The tributaries of the dorsal vein of the penis lying in the fat anterior to the capsule are secured and coagulated and the fat pushed aside by blunt dissection Vessels in the front of the capsule are sealed by diathermy coagulation A transverse incision is now made over the right lateral lobe of the gland midway between the bladder neck above and the apex of the gland below This is deepened through the capsules until the adenoma is seen Adequate suction is essential to remove the blood as oozing is free at this stage Using long scissors curved on the flat the lower capsule flap is undermined and seized with T shaped capsule forceps A similar capsular incision is made over the left lateral lobe linking up with that over the right the lower leaf undermined and held by a second T shaped forceps The upper flap is drawn upwards by a toothed volsellum exposing the adenomatous mass A stay suture is passed through the edge of each capsular flap using a boomerang needle knotted and held in hæmostats Elevating the lower capsular flap the lower limits of the lateral lobes are defined freed by means of the long scissors and the urethra then divided with scissors at the apex of the prostate The lateral recess packs and the retractor are now removed Elevating the lower capsular flap by means of the stay suture the surgeon insinuates the index finger between this structure and the adenomatous mass Enucleation proceeds from below upwards The mass remains attached at the neck of the bladder from which it is dissected away The adenomatous mass having been removed a temporary pack is placed in the prostatic cavity and the self

retaining retractor replaced The pack is removed and the prostatic cavity inspected for any bleeding points or residual adenomata The cavity should be left perfectly smooth The posterior lip of the vesical outlet is now grasped and a wedge excised to prevent subsequent obstruction A suitable sized (18–22 F) catheter is now passed and will usually enter the bladder *without difficulty, but* may have to be guided through the vesical neck The transverse capsular incision is now closed with a continuous suture of No 1 chromic catgut introduced with a boomerang needle The retropubic space is swabbed free of clots and a drain left down to the suture line The wound is now closed in layers and the catheter irrigated until the efflux is clear Four ounces of lotion, preferably 3 8 per cent sodium citrate, are introduced and the catheter spigotted Bilateral vasectomy is carried out One hour later the spigot is removed and the catheter allowed to drain continuously Irrigation is only employed if drainage appears to be impeded and is carried out with strict aseptic technique The catheter is removed on the third day and the patient allowed out of bed If there is any urinary leakage the catheter is re inserted for a few days The operation is usually conducted under an umbrella of sulphonamide and an antibiotic

The number of vessels encountered and the amount of hæmorrhage vary considerably and if necessary an intravenous drip transfusion should be set up If performed under anæsthesia with hexamethonium bromide the operation can be carried out with a minimal loss of blood The transverse approach which incidentally can be utilized for many other operations on the bladder or prostate has the distinct advantage that it enables the patient to cough without discomfort or the risk of developing an incisional hernia Millin s self retaining retractor functions far more satisfactorily when a transverse incision is used

Suprapubic Prostatectomy with Closure

The latest modification of this operation is that described by Wells and is developed from that advocated by Wilson Hey Hey made the important observation that it is sepsis that kills the patient, and that sepsis is introduced by instrumentation He therefore vetoes any preliminary catheterization or cystoscopy An assessment of renal function and the amount of residual urine is carried out by means of intravenous pyelography Wells temporizes on this point and is prepared to cystoscope the patient if the diagnosis is in doubt The important point is that if cystoscopy is

carried out it should be followed immediately by aseptic prostatectomy when this is indicated

The operation is carried out under spinal anæsthesia which Wells considers essential in order to deal with the problem of hæmorrhage during the course of the operation Blood pressure is maintained at a constant level by a saline intravenous drip containing 1 nor adrenalin

A midline suprapubic incision is made The bladder is opened and the prostate and ureteric orifices visualized A Tiemann's No 6 catheter is passed down the urethra from the bladder and out of the meatus The tissue to be removed is now outlined by making a diathermy incision round the vesical aspect of the prostate The anterior and lower parts of the lateral lobes are now enucleated with the finger after which they are grasped with Duval forceps and held up enabling the urethra to be divided proximal to the verumontanum with the diathermy needle The enucleation of the lateral lobes is now completed and two cuts made with the diathermy needle in the rim of the prostatic cavity at three and nine o'clock—internal sphincterotomy These cuts divide the muscle of the internal sphincter and enable the whole cavity to be seen plainly and bleeding vessels to be sealed with diathermy The search for bleeding vessels is continued until the cavity is dry and this may occupy only five minutes or as long as twenty minutes A 21F catheter is now attached to the bladder end of the indwelling Tiemann catheter and pulled down through the urethra The prostatic cavity is packed with two pieces of Gelfoam soaked in thrombin placed in apposition with the side walls and held in position with a pack of oxycel gauze The catheter is retained in position by a nylon suture through its tip brought up through the bladder and abdominal wall and fixed externally The bladder is closed in two layers and the abdominal wall closed leaving a drain in the cave of Retzius The vasa are tied The catheter is irrigated with citrate solution, 3 oz being left *in situ* and the catheter then spigotted

Post operative Care The urethral catheter remains spigotted for forty five minutes The bladder is then emptied and washed out three or four times with 5 per cent citrate solution Three ounces of citrate are then introduced and the catheter spigotted again This procedure is repeated three or four times at intervals of forty five minutes until the effluent is free from clots The catheter is then connected up with sterile tubing to a receiver at the side of the bed Normally it is removed on the fifth day In old or feeble patients with bladder atony or in cases of urinary leakage from the wound, however, the catheter is retained for a longer period

up to a maximum of three weeks. The operation is carried out under an "umbrella" of penicillin and sulphatriad which are stopped on the fifth day when the catheter is removed. After this acidification of the urine is produced with acid sodium phosphate. The patient is allowed out of bed on the day after the operation.

Retention Complicating Prostatic Enlargement

It is now realized that the most important factor in the management of acute retention due to prostatic enlargement is the avoidance of sepsis and Wilson Hey was the first to advocate immediate aseptic prostatectomy without any preliminary catheterization in all cases. He pointed out that the obstructed kidney is peculiarly vulnerable to superadded acute sepsis and that free drainage of the obstructed kidneys cannot be guaranteed with certainty until the prostate has been removed. Further, that the bleeding which so often occurs during decompression of the distended bladder comes from blood vessels on the surface of the prostate. It is undoubtedly true that in the majority of cases this is correct but in acute retention of sudden onset it is not always possible to carry out immediate prostatectomy and catheterization if properly conducted will relieve the patient without producing a catastrophe. In chronic retention with high nitrogen retention considerable improvement can be brought about in the patient's condition by continuous drainage if this is carried out with a small suprapubic tube inserted high in the bladder as suggested by Riches. In this manner certain patients suffering from chronic retention may be converted from hopeless to reasonable operative risks. The virtue of the suprapubic drain as opposed to an indwelling urethral catheter is the considerably lesser tendency for infection to develop in the bladder. Decompression should be conducted slowly, being controlled by the effect on the blood pressure and the amount of blood in the urine draining from the bladder. A cover of an antibiotic should be used during the period of drainage.

CARCINOMA OF THE PROSTATE

The treatment of this condition is now largely influenced by the knowledge that the majority of cases will be affected profoundly by œstrogens. Carcinoma of the prostate as a rule progresses slowly and the average age of onset is sixty five. These facts make for difficulty in assessing the efficacy of treatment. Radical surgery is more favoured in America than in this country, where the opinion is that if the condition can be diagnosed on clinical grounds, radical

surgery is unlikely to be successful in that the disease will have spread beyond the confines of the area which can be excised

Perineal prostatectomy has always been regarded with suspicion in that even in the best hands it may give rise to permanent incontinence or fistula both major disasters from the point of view of the patient Retropubic and Wilson Hey suprapubic prostatectomy are alternatives but of limited application Before radical surgery is undertaken it is wise to perform an adequate biopsy and this is preferably carried out by perineal dissection Needle puncture biopsy is unsatisfactory and transurethral punchings may not include the carcinomatous area An alternative method of establishing the diagnosis is an estimation of the level of the acid serum phosphatase bearing in mind that anaplastic rapidly growing tumours may not be associated with any alteration in it King and Armstrong first described an efficient method for its estimation, the normal level being from 0 to 3 5 units A reading of 3 5 to 5 0 is suggestive if there is clinical evidence to support the diagnosis of carcinoma 5 0 to 10 is strongly suggestive and over 10 is diagnostic The alkaline serum phosphatase may also be raised particularly if osteoblastic secondary deposits in bone are present

A rise of over ten in the acid serum phosphatase may occur in jaundice hyperparathyroidism Paget s disease and secondary deposits in bone from a primary focus anywhere in the body The highest values may be found in Paget s disease but here the alkaline serum phosphatase reaches higher levels than are encountered in prostatic cancer an important point as the radiological appearances of secondary prostatic carcinoma in bone resemble those of osteitis deformans closely

A reduction in the proportion of androgens to œstrogens creates conditions unfavourable to the growth of carcinoma of the prostate Bilateral orchidectomy and the administration of synthetic œstrogens such as stilbœstrol first synthesized by Dodds in 1938 and dienœstrol over a period of time produce the same result Fergusson has demonstrated this by repeated biopsies of the prostate in patients undergoing treatment with stilbœstrol Moreover secondary deposits of the growth in bones are usually similarly influenced Œstrogen therapy improves the patient s general health and delays the onset of or averts urinary obstruction It is common to find that considerable amounts of residual urine are eliminated completely as a result of treatment Nevertheless the value of œstrogen therapy should not blind one to the possibilities of radical surgery in cases deemed to be operable approximately 5 to 10 per cent of all cases Should retention arise it should be

treated by transurethral surgery. As stated earlier, œstrogens will sometimes fail completely, whereas castration may succeed. Occasionally both measures prove valueless. In this case reduction of androgen output can be attempted by suppressing the activity of the pituitary with radiotherapy or by bilateral adrenalectomy, as the adrenals elaborate androgen. Androgens cause both normal and neoplastic prostatic tissue to grow and secrete and produce 17-ketosteroid excretion in the urine.

Stilbœstrol is well absorbed when taken by the mouth and is inexpensive. It must be given in adequate dosage, not less than 15 to 20 mgm. a day in the first place. The rate and degree of response will vary in different subjects, but once recession of symptoms has occurred a small maintenance dose should be given permanently. Correct dosage can be controlled by estimation of the acid serum phosphatase. Stilbœstrol may produce troublesome side effects, such as painful enlargement of the breasts with pigmentation of the areolæ, œdema of the ankles, cardiac symptoms and hot flushes. Dienœstrol is better tolerated by some patients and, being more potent, is given in smaller doses. A marked effect on metastases in bones may be noted. Pain may disappear and radiographic examination may show arrest or recession of growth. Anæmia, which is found commonly in carcinoma of the prostate, may also be influenced favourably.

When œstrogens fail to influence the growth of bony metastases radiotherapy may prove helpful. When they have no effect on the primary growth or cease to influence it, bilateral orchidectomy should be carried out. Huggins, on the other hand, advises orchidectomy in the first place, followed later by œstrogen therapy.

Bilateral orchidectomy is a simple procedure and should be of the intracapsular variety. This leaves two testicular pads in the scrotum, thus avoiding any mental distress the patient might experience from an empty scrotum. A midline anterior scrotal incision is made and first one and then the other testicle delivered into the wound. An anterior incision is made through the tunica albuginea from the upper to the lower pole, exposing the seminiferous tubules, which are sponged away by gauze dissection down to the mediastinum testis. The tunica is now closed with a running stitch and the testicle returned to the scrotum. The scrotal incision is closed.

Both the testicle and adrenal are stimulated to produce androgen by the anterior pituitary through its acidophilic cells, which produce adrenocorticotrophic hormone (ACTH) and gonadotrophic hormone. The androgen production of the adrenal cortex is depressed by

cortisone and Hayward has suggested this substance may prove useful in cases in which castration and œstrogens have failed. The alternative, namely bilateral removal of the adrenals, must be regarded as hazardous.

URETHRAL STRICTURE

Stricture in the anterior urethra is usually amenable to treatment by intermittent dilatation, but can never be regarded as completely cured. Unless a patient will submit to periodic dilatation trouble

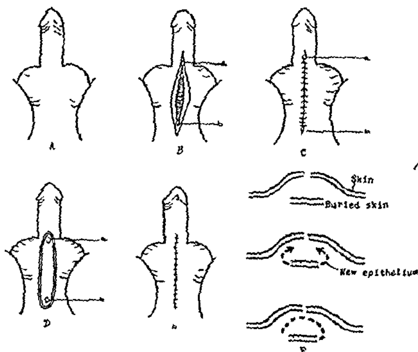


FIG 117 Reconstruction of the male urethra in cases of stricture
(By courtesy of M. J. Swinney and the Editor, Brit. Journ. of Urology)

will develop sooner or later. Denis Browne has pointed out that a plastic operation on similar lines to that practised for hypospadias should cure the patient. Swinney has reported on a successful series of cases treated by this method. The essential steps in the operation are as follows. The urinary stream must be diverted and this is best effected by suprapubic cystostomy, perineal urethrostomy being less satisfactory. All scar tissue must be excised through a median perineal incision, in effect an external urethrotomy. This excision may involve a large part of the corpus spongiosum and any overlying sinuses. Normal urethra is brought to the surface at either end of the excised area, which is then covered by suturing

the overlying skin as a bridge between the two open ends of the urethra When healing of the new urethral roof is complete the skin bridge is buried by undercutting and drawing together the perineal skin on either side of it Skin approximation is best carried out with interrupted sutures held in position by beads (Fig 117)

The risk of the growth of hair in the new urethra is not great as experimental work has shown that the hair follicles in buried skin strips atrophy Accurate suture of the skin edges and new urethral orifices is essential to avoid the development of contracture, but cortisone might be used during part of the treatment to reduce fibrosis to a minimum

One of the problems which involves all operations on the penis is the pain and ill effect on the suture lines which arise from the occurrence of erections The administration of œstrogens such as stilbœstrol shortly before and after operation will effectively meet this difficulty and has no permanent adverse effects

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PART V—VASCULAR SURGERY

CHAPTER XXI

PERIPHERAL BLOOD VESSELS

C G ROB

ARTERY AND VEIN GRAFTING

Introduction

CARREL in 1908 preserved a dog s aorta for thirty days in isotonic saline at 0° to 1 C and then grafted it into another dog This was the first successful artery graft Since this experiment much progress has been made and it is now standard practice to preserve human arteries for long periods and then to graft them into another individual with a very good chance of a successful functional result

Homografted tissues nearly always die and this is true of artery grafts Nevertheless they work and although the grafted artery eventually disappears it survives for a sufficient period to allow the host s tissues to grow in and form a new blood vessel What probably happens is that the grafted artery is kept open by the force of the blood flow a new layer of intima forms from the deposition of cells out of the blood on to the surface of the graft and to a small extent by the growth of intima from the ends of the host vessel The media and adventitia are replaced by the host s fibrous tissue but the elastic fibres which are extracellular structures survive and play an important part in maintaining the stability of the new channel The graft therefore acts as a scaffold which maintains the blood flow sufficiently long for the tissues of the host to grow in and form a new blood vessel

Preservation of Grafts in the Artery Bank

An essential aspect of artery grafting is to have an efficient artery bank because it is by this means alone that suitable arteries can be readily available when needed Gross Bill and Pierce of Boston (1949) have developed a technique of artery banking based on the researches of Carrel the results have been good but the method is time consuming and the arteries survive for only four to six

weeks A better method is that developed in collaboration by Hufnagel of Washington and Eastcott of St Mary s Hospital London (1950 1952) They take arteries from suitable donors who must have been dead for less than eight hours who have macroscopically normal arteries and who mu t not have suffered from a transmittable disease The arteries are removed with a full aseptic technique cleaned down to the adventitia all branches are cut so as to leave a stump about 1 cm long and then they are washed in isotonic saline They are next placed in sterile pre cooled tubes and frozen as rapidly as possible using liquid nitrogen which has a temperature of — 194° C or a mixture of carbon dioxide snow (dry ice) and alcohol the temperature of which is — 79° C Both these substances are readily available the carbon dioxide snow in any medium sized town and liquid nitrogen wherever there is an oxygen factory oxygen is manufactured by liquefying air and distilling it the liquid nitrogen being a by product of this process Once the arteries have been frozen they are stored in a deep freeze containing a chamber of carbon dioxide snow (dry ice) at a temperature of — 70° C or less When required the arteries are thawed as rapidly as possible by immersing them in saline at blood heat 40 C The method may be summarized as freezing as rapidly as possible storing as cold as possible and thawing as rapidly as possible it has the advantage that arteries can be stored for long periods and perhaps indefinitely without deterioration

After this treatment the artery is indistinguishable from normal when examined with a microscope The reason for this is probably a question of the size of the ice crystals which form within the cells when they are frozen With slow freezing the crystals are large and disrupt the cell with rapid freezing and thawing only small crystals form and the cell survives A dramatic indication of the way in which cells can survive freezing to these very low temperatures is given by the work of Polge and Rowson (1952) they froze bulls' spermatozoa to — 79° C in a mixture containing 20 per cent glycerol The spermatozoa were stored at this temperature for periods up to eight days and then used for the artificial insemination of thirty eight cows a pregnancy rate of 79 per cent resulted

The preservation of arteries by freezing has two disadvantages an expensive deep freeze is needed and the grafts are difficult to transport from hospital to hospital For some time Hufnagel and Hyatt with their colleagues at the Naval Medical Centre at Bethesda Maryland and Eastcott and myself at St Mary s Hospital London have been trying to eliminate these disadvantages Preservation by *Freeze Drying* is now the method by which both institutions

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are suitable for an artery graft a surprisingly high figure In the case of gangrene or threatened gangrene one is dealing with an entirely different problem The object here is to save the limb and a graft is justified whenever the anatomical situation permits



Fig 118 Arteriogram showing a thrombosed segment of the superficial femoral artery Note the irregularities above and below the block these are due to plaques of atheroma



Fig 119 Post operation arteriograms on the patient shown in Fig 118 The thrombosed segment has been replaced by an artery graft

age or another disease are contra indications but mild angina pectoris or evidence of cerebral arteriosclerosis are not

Eastcott in a Hunterian Lecture delivered at the Royal College of Surgeons in March 1953 reviewed our experience at St Mary s Hospital with artery grafting Figs 118 and 119 illustrate a typical case this patient had severe intermittent claudication

bank their arteries Freeze dried arteries can be stored at room temperatures and transported with as much ease as a tube of sterile distilled water The results in experimental animals have been satisfactory in man we have only used them for six months Over this short period they have proved to be the equal of arteries preserved in other ways We believe that freeze drying will be the method of choice for banking blood vessels and propose in the near future to publish the technique we employ

The indications for artery grafting include the correction of certain congenital abnormalities of the great blood vessels such as a coarctation of the aorta which is too long for a primary anastomosis bridging the defect after the excision of an aneurysm the repair of a wound of an artery, and on occasions the reconstruction of an artery which has been sacrificed during the excision of a new growth But the most frequent and important indication is for the treatment of ischæmic symptoms in the lower limb

Artery Grafting for Ischæmia of the Limbs

Obliterative vascular disease has been investigated by Boyd (1950), and as a result he has produced the following classification —

1 Primary Thrombosis of the Popliteal Artery
2 Juvenile Obliterative Arteritis (Buerger s Disease)
3 Senile Obliterative Arteritis
4 Primary Thrombosis of the Superficial Femoral Artery

The importance of Boyd s work is that it has demonstrated clearly that the symptoms of obliterative vascular disease are due in the majority of patients to a localized thrombosis in a major vessel In other words these patients are suffering from a generalized disease affecting many of their arteries but the symptoms in the limbs are frequently due to a local process Artery grafting provides a method by which the local area of occluded artery can be replaced with a new vessel It has been our experience on the Surgical Unit at St Mary s Hospital that fully two thirds (66 per cent) of all patients with intermittent claudication or gangrene of the toes have a localized block in the main arteries anatomically suitable for an artery graft This does not mean that two thirds of these patients will be benefited by an artery graft, obviously if the patient has angina pectoris and intermittent claudication it will be a waste of time to have cured intermittent claudication occurring at 100 yards for the patient to be stopped by the worse pain of angina pectoris at 150 yards In fact about one tenth (10 per cent) of patients with intermittent claudication

are suitable for an artery graft, a surprisingly high figure. In the case of gangrene or threatened gangrene one is dealing with an entirely different problem. The object here is to save the limb and a graft is justified whenever the anatomical situation permits.



Fig. 118. Arteriogram showing a thrombosed segment of the superficial femoral artery. Note the irregularities above and below the block; these are due to plaques of atheroma.



Fig. 119. Post-operation arteriograms on the patient shown in Fig. 118. The thrombosed segment has been replaced by an artery graft.

age or another disease are contra-indications, but mild angina pectoris or evidence of cerebral arteriosclerosis are not.

Eastcott in a Hunterian Lecture delivered at the Royal College of Surgeons in March 1953 reviewed our experience at St. Mary's Hospital with artery grafting. Figs. 118 and 119 illustrate a typical case; this patient had severe intermittent claudication

but no angina pectoris The pre operative arteriogram showed that he had a thrombosis of the superficial femoral artery, and that the artery above and below the area of complete block was diseased and atheromatous At *operation* the occluded segment of artery was resected and a graft inserted the presence of atheromatous plaques in the host vessel near to the suture line made the procedure more difficult, but by no means impossible as shown by the successful post operative result (Fig 119)

The technique of artery grafting may be divided into four phases (i) the resection of the diseased segment (ii) the preparation of the graft (iii) the insertion of the graft and (iv) the post operative care

The diseased segment is usually the distal superficial femoral and proximal popliteal artery This is best approached through an incision along the line of the vessel with the patients lying on their side The upper (good) leg being flexed fully at the hip and to 90 degrees at the knee the lower (bad) leg is fully extended at both the hip and the knee joints The incision cuts straight through to the artery dividing the adductor magnus muscle in its distal part No important structures are damaged and all collateral vessels avoided, it is exceptional for more than an occasional artery forcep to be needed The artery is isolated from the vein and nerve and the thrombosed segment removed between clamps It is not necessary to put on the proximal clamp until the surgeon has completed the distal anastomosis—the thrombosis in the diseased segment prevents bleeding

The Preparation of the Graft After thawing or rehydrating in the case of a freeze dried artery the branches on the graft are tied with fine silk and the adventitia is stripped back for a distance of about 1 cm from each end This is important otherwise the needle during the anastomosis may carry small portions of adventitia into the lumen and thrombosis result The next step is to cut the graft to the right length the usual fault is to leave it too long An artery graft must be inserted under considerable tension we advise that the gap between the two ends of the recipient s artery be measured and the graft cut to a length about 20 per cent less than this If the graft is not under tension it may thrombose or an aneurysm form a few days later

The Insertion of the Graft Blalock s clamps or tape tourniquets are used to hold and approximate the ends of the recipient s artery Two or three interrupted everting mattress sutures are inserted and the anastomosis completed with a continuous everting mattress suture of fine silk The distal clamp is removed first and then the

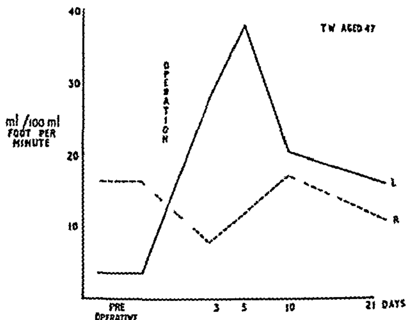


Fig 120 Foot blood flow before and after an artery graft Note the marked reactive hyperæmia in the left foot These readings were obtained with a plethysmograph and have been recorded in mls of blood per 100 ml of foot per minute

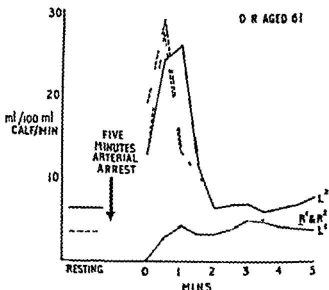


Fig 121 Calf blood flow before and after a successful artery graft Note the increased response to five minutes arterial occlusion in the left leg as compared with the pre operation readings These readings were also obtained with a plethysmograph and have been recorded in mls of blood per 100 ml of calf per minute

thrombosis is recent or if the collateral circulation is failing but unchanged if the collateral circulation has become established After operation the foot blood flow (skin) rises to five to ten times the pre operation level and then gradually settles down to equal that on the normal side (Fig 120) The calf blood flow (muscle) is unchanged at rest before a graft when compared with the normal side and in a patient with an established collateral circulation, we have not measured the response to exercise but we have measured the response to temporary occlusion of the femoral artery which may be comparable The reactive hyperemia in the calf muscles after five minutes occlusion of the femoral artery is before grafting reduced to nothing or almost nothing in a patient with severe intermittent claudication after grafting the reactive hyperemia shows an increase in the blood flow of four or five times when compared with the resting level (Fig 121)

Vein Grafting

Replacing a diseased segment of an artery by a vein graft has certain obvious advantages an artery bank is not needed the graft is autologous and not homologous and the long saphenous vein is readily obtained during an operation on the femoral or popliteal arteries Fontaine and Hubinot (1950) have considerable experience with this method and their results have been good We have tried this technique on the Surgical Unit at St Mary s Hospital and Figs 122 and 123 show arteriograms before and six weeks after a vein graft In our opinion vein grafts are inferior to artery grafts for two reasons one the vein dilates as shown in Fig 123 and two it is technically a great deal harder to put in a vein graft particularly if the host vessel is arteriosclerotic It has been stated by several authorities that a vein grafted into an artery hypertrophies and eventually comes to resemble the host vessel our experience has not borne this out The wall of the vein increases in thickness and there may be some slight increase in the elastic and muscular fibres but the great bulk of the increase consists of fibrous tissue The arterialization of a vein noted in arteriovenous fistulæ is not seen in grafted veins An alternative procedure is that reported by Kunlin (1951) of Paris he uses a length of saphenous vein to bypass an arterial block The vein is anastomosed end to side above and below the thrombosed segment of artery The advantage of this method is that no collateral vessels are damaged He has treated seventeen patients with obliterative arterial disease in this way in most the vein graft connected the common femoral to the popliteal artery ten of these patients left



FIG 122 Arteriogram showing a thrombosis of part of the popliteal and superficial femoral arteries



FIG 123 The post operation arteriogram on the patient shown in Fig 122 A vein graft was inserted six weeks before Note the dilatation and the decrease in size of the collateral vessels

hospital improved and in eight of these a pulse was palpable at the foot when it had been impalpable before Martin (1952) has performed this bypass operation on 12 patients in 4 the result has been satisfactory and in one of these the graft has remained patent for two years

In War The previous remarks refer to vein grafts in patients with diseased or arteriosclerotic vessels but in war and other circumstances where the arteries of the host are normal a vein graft may be preferable to an artery graft The main objection to vein grafts in arteriosclerotic patients is that they are technically difficult to put in because one is sewing a thin walled vein to a

thick walled artery in the plaques of atheroma at or near to the suture line this does not apply if the host vessel is normal

The advantages of using the patient s own saphenous vein are great and in war surgery an artery bank is unnecessary A few vein grafts were used in the 1939–45 war but mostly with the non suture technique over a vitellium tube—the results were not very encouraging The Korean War has provided an opportunity for the logical extension of this work the use of lengths of the patient s own saphenous vein to bridge gaps in his arteries with a meticulous suture anastomosis and no vitellium tubes the early results in the United States Army have been excellent A school of vascular surgery has been organized in Korea where field surgeons are trained on dogs to insert vein grafts So far more than forty vein grafts have been inserted into battle casualties with major vessel injuries (popliteals femorals carotids etc) and thirty five of these have remained patent A great achievement

Disobliterative Endarterectomy

Dos Santos (1947) was one of the first surgeons to treat ischæmic symptoms in the lower limbs by a direct attack on the area of arterial block as opposed to indirect methods such as sympathectomy He performed the operation of disobliterative endarterectomy which has been modified by Reboul (1950) and consists in exposing the thrombosed segment opening the vessel removing the clot and repairing the artery The clot separates with surprising ease and if the patient is given an adequate course of heparin many of these arteries remain patent and the patient s symptoms are relieved Forty (1952) has reported a successful disobliterative endarterectomy of the external iliac artery The success rate with this operation is not high enough however, and Fontaine and Hubinot (1950) who have performed it on twenty occasions report that their results have been variable whilst Reboul and Laubry (1950) report that of ninety three disobliterations forty four (47 per cent) remained patent thirty eight clotted again and eleven patients died

ANTICOAGULANTS

The 1948 edition of Recent Advances in Surgery contained a chapter on the anticoagulants Since then they have been used on an even greater scale for a wide variety of diseases both medical and surgical The best anticoagulant is without doubt heparin not only does it work quickly but there is an efficient antidote in

protamine sulphate, the dose of which is 5–10 ml of a 1 per cent solution The disadvantage of heparin is its cost Dicoumarol and allied drugs are inferior to heparin for several reasons the response is slow and variable the effect is cumulative and there is no antidote They are cheap however It is possible that in the near future a slightly less pure but cheaper form of heparin may become available

Regional Heparinization The disadvantage of systemic anti coagulant therapy in vascular surgery has been the high incidence of hæmatoma formation in the immediate post operative period Murray and Best (1938) first suggested regional heparinization as a safer alternative They recommended this method for use after a vascular anastomosis As used to day (Freeman and Gilfillan 1952) a very fine polythene tube is inserted into the vessel and passed to the region of the anastomosis for example after a porta caval shunt the tube may be passed up a branch of the inferior mesenteric vein A constant saline infusion containing about 200 mgm (26 000 international units) daily is maintained for up to a week after which the tube is withdrawn It is claimed that this method prolongs the clotting time of the blood in the region of the anastomosis but has less effect on the systemic clotting time This finding has never been proved this dosage of heparin often prolongs the clotting time of the systemic blood to twenty minutes or more and may produce a greater prolongation regionally but in all published work this has been an assumption and not a proven fact The idea however is attractive

Trypsin Recently Innerfield Schwartz and Angrist (1952) have used intravenous trypsin in experimental animals and twenty patients Their results show that trypsin by the intravenous route produces no untoward reactions if given slowly, that it has anti coagulant properties and most important that it has a lytic effect upon artificially formed thrombi This latter observation may have far reaching results in the management of patients with thrombotic or embolic episodes in either arteries or veins The exact mechanism by which it produces lysis of an intravascular thrombus has yet to be worked out

Long term Anticoagulant Therapy Marple and Wright (1950) report that dicoumarol may be given to out patients over long periods They reduce the prothrombin activity to 25 per cent of normal and control it by an estimation of the prothrombin level every third day They stress that this treatment can only be carried out in an intelligent and co operative patient The advantages of such a *regime* for patients with recurrent thromboses are obvious

MANAGEMENT OF INTERMITTENT CLAUDICATION

The treatment of this symptom by artery grafting has been discussed Other methods are numerous Hamilton and Wilson (1952) have recently subjected some of the standard treatments to a critical analysis A group of patients had their claudication measured by the single test of being asked to walk at their ordinary pace over a pair of steps 18 in high the number of circuits com pleted and the time taken before the pain developed were recorded First a group of patients were observed over a period of several weeks without any treatment being given and remarkable fluctua tions in the exercise tolerance were noted It was decided therefore that any single observation was without value and that repeated observations on each patient extending over a considerable period of time were necessary to assess the effect of each method of treat ment

Intermittent Venous Occlusion

This produced some improvement but the treatment was carried out on in patients The response to simple rest in bed was then compared with intermittent venous occlusion and it was found to be equally effective

Drugs

A number of patients were given a course of the following drugs priscol vitamin E methyl testosterone nicotinic acid dihydro ergotamine, papaverine, and aminophylline, As a control every patient received an equivalent course of a dummy substance, similar in appearance but inert in content Hamilton and Wilson report that none of the forms of drug therapy used produced an increase in exercise tolerance beyond that occurring naturally in the course of the disease or beyond that produced by the inert preparations

Edwards and his colleagues (1952) have studied the response of eighty four patients with peripheral vascular disease to intra arterial injections of priscol papaverine alcohol acetylcholine and histamine Most of these patients were suffering from senile obliterative arterial disease their results have been encouraging Of these drugs priscol and papaverine were the most effective the former in a dosage of 5–100 mg in 10–20 ml of isotonic saline, and the latter in a dose of 40 mg of papaverine sulphate in 20 ml of isotonic saline

Myoneurectomy

Boyd and Learmonth (1949) thought of this operation independently, and they have performed it on a number of patients with intermittent claudication The nerve supplying the muscle which claudicates is divided and the patient can then walk until he is stopped by fatigue or the claudication of another muscle Boyd (1949) found that the difficulty was to decide which muscle was claudicating, therefore he has worked out the area of skin reference of pain from the various muscles of the lower limb Pain from the soleus is felt on the back and inner side of the calf of the leg and along the medial border of the sole of the foot Pain from the gastrocnemius over the back of the knee joint extending up the lower third of the back of the thigh and a similar distance down the back of the calf of the leg Pain from the muscles in the anterior compartment of the leg is felt over the anterior and lateral surface of the leg and dorsum of the foot

Tenotomy of the Tendo Achilles

This operation was first used by Boyd (1949) for the treatment of patients with severe intermittent claudication and it has now replaced myoneurectomy in his clinic for the treatment of patients of this type The tendon is divided with a tenotome the operation takes a few moments and can be performed on an out patient After a tenotomy the patient can walk satisfactorily without pain In our experience at St Mary s Hospital this operation gives good results in selected patients but it may have to be repeated at intervals The claudication is relieved but in many patients it recurs after three to nine months examination of these patients shows that the tendon although lengthened has reunited a second or even a third tenotomy may be necessary to keep the intermittent claudication under control

Clinical Plethysmography

The plethysmograph has been essentially a piece of research apparatus but Goetz (1949) has produced a portable digital plethysmograph with which the blood flow through a finger or toe can be measured This apparatus can be worked with sufficient ease for it to be of use to a clinician engaged in the diagnosis and treatment of peripheral disease It permits measurement of the actual rate of blood flow through a digit and for example it is of particular value in determining the completeness of a sympathectomy

Aortography

Although aortography is not new, dos Santos described in 1929 a technique essentially similar to that in use to day, it is being performed more often There are two methods—the direct and the retrograde In the direct method a wide bore needle is inserted into the abdominal aorta from the back the needle passing just below the left twelfth rib In the retrograde method a fine polythene catheter is passed up the radial or ulnar arteries into the aorta In both techniques about 40 ml of a 70 per cent solution of pyelosil or diodrast are injected as rapidly as possible under general anæsthesia and X rays taken during and just after the end of the injection Most authors including Deterling (1952) prefer the direct method for visualization of the abdominal aorta they have found it relatively safe and the picture is better than that obtained by the retrograde route The thoracic aorta however is best demonstrated by the retrograde technique

Phenol Sympathetic Block

Haxton in 1949 reported that he had injected an aqueous solution of phenol into the lumbar sympathetic chain of 220 patients In 90 per cent a dry and warm foot resulted and in 60 per cent the effect was lasting the foot remaining warm and dry for months The technique he recommended consisted of a preliminary injection of 2 ml of a 4 per cent procaine solution if this produced evidence of sympathetic interruption without symptoms of numbness or paralysis he then injected 10–12 ml of a 10 per cent solution of phenol in water

CONSERVATIVE AMPUTATIONS FOR GANGRENE

Gangrene of the toes or forefoot is usually associated with a main vessel block but in a minority of patients the block is peripheral In some of these latter patients a conservative amputation can be performed Diabetics may develop one of two types of gangrene they may have arteriosclerosis and their gangrene be similar to arteriosclerotic gangrene in anyone else or they may develop gangrene due to an infection of a toe

The main points in the selection of patients for a conservative amputation are the presence of palpable pulsation in the popliteal posterior tibial or dorsalis pedis arteries evidence of infective gangrene in a diabetic or an arteriogram which shows that the block is in the arteries of the toes or the forefoot Under these circumstances primary healing will occur if the line of section passes

through healthy tissue There is an increasing tendency to avoid all set or formal amputations in these patients Fig 124 shows a foot one year after the second and third toes the corresponding meta tarsals and the adjacent soft parts had been excised from a diabetic patient aged seventy six, primary healing occurred and the patient left hospital within two weeks

Of the formal amputations many surgeons prefer the site of election in the thigh because of the greater certainty of primary healing but others are using more conservative operations even for patients with main vessel occlusions Of the more conservative operations, the transmetatarsal is one of the most popular and Warren Crawford, Hardy and McKittrick (1952) report 62 8 per

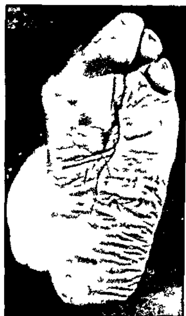


Fig 124 A foot one year after excision of the second and third toes the corresponding metatarsals and the associated soft parts for infective gangrene in a diabetic patient aged seventy nine years

cent healing in a group of forty three transmetatarsal amputations performed on forty patients with arterial deficiency only four of these patients had a lumbar sympathectomy

SYMPATHECTOMY

It is probable that sympathectomy is of value in assisting healing after an amputation for gangrene Two points should be mentioned however First after a sympathectomy the blood flow through the skin is greatest during the first forty eight hours (Lynn and Barcroft 1950) after that it falls progressively but usually remains a little above the pre operation level Secondly the standard operation of

lumbar sympathectomy removes 1 in of chain centred on the third lumbar vertebra This procedure produces vasodilation and abolishes sweating from the skin of the limb below the knee joint The practical importance of this is that the standard lumbar ganglionectomy will aid healing after an amputation below the knee but at the site of election through the thigh no benefit accrues because the denervated area does not remain attached to the patient to denervate the skin flaps of a mid thigh amputation it is necessary to remove the first lumbar ganglion as well Similarly, in intermittent claudication the area denervated should include the region of the block in the main artery because it is around this that the collateral vessels must form.

Ganglionectomy or Pre-ganglionic Section Kinmonth and Hadfield (1952) have compared the results of these two operations in a group of patients suffering from Raynaud s disease They have found the clinical results of the two operations to be the same for Raynaud s disease but that side effects, such as a Horner s syndrome and nasal congestion occur with ganglionectomy and not pre ganglionic section For this reason they prefer the latter operation

THE TREATMENT OF AORTIC AND OTHER ANEURYSMS ARTERIAL SPASM

During the last few years several ingenious methods for the treatment of arteriosclerotic aortic aneurysms have been described Linton (1951) recommends intrasaccular wiring A fine cannula is introduced into the aneurysm and 30 gauge stainless steel wire threaded through this and into the sac His method differs from previous attempts at intrasaccular wiring in two ways He inserts a great deal more wire than any of his predecessors the shortest length he has introduced was 100 ft and the longest 965 ft He makes multiple punctures with the cannula to get this length of wire into the aneurysm the object is to fill the whole sac with wire It is interesting that he is willing to wire an aneurysm after rupture has occurred There is usually only a small leak at first and he has wired six aneurysms of this type Three of these six patients died within one week two lived fourteen and eighteen months respec tively and one patient has lived for two and a half years and survived a second wiring for another rupture He has wired seventeen aortic aneurysms with benefit to fifteen patients and no benefit to two

Poppe (1949) has wrapped aneurysms of the aorta in cellophane

There are several different kinds of cellophane—some produce no tissue reaction others produce intense fibrosis In this method polythene cellophane has been used, which produces an intense foreign body fibrous tissue reaction A sheet of this substance has been placed round an aortic aneurysm in nine patients four survived for from one to three years The fibrous tissue reaction takes time to develop and the maximum benefit was not apparent for between three and four months The active principle in polythene cellophane which causes the fibrosis is decetylphosphate Berman and Hill (1952) have used this substance mixed with olive oil for the periaortic injection of aneurysms In no patient could reduction in the size of the sac be shown, but a thick layer of fibrous tissue can be relied on to form, and this may limit the further expansion of the aneurysm Symptoms were relieved in most patients but rupture has occurred This method appears to be worth an extended clinical trial as it is a minor procedure relatively free from risk

The treatment of aortic aneurysms by artery grafting is of value for anatomical reasons the aneurysm must be situated either between the left subclavian artery and the diaphragm or below the renal vessels Brock (1952) has reported a success with this method and we have found it satisfactory

Temporal Arteritis

Of recent years interest in this condition which was described by Jonathan Hutchinson has been renewed The patients suffer from fronto temporal headache the temporal artery is thickened tortuous tender and nodular and the overlying skin may be red Excision of the abnormal vessel relieves the headache but the local process in the temporal arteries is usually part of generalized arterial disease

Cirsoid Aneurysm

This term is taken to mean congenital arterio venous fistulæ of the vessels of the scalp usually the superficial temporal artery and vein The condition becomes apparent during adult life and the treatment is difficult The best method is probably to tie the external carotid artery and then to turn down a scalp flap con taining the aneurysm which is dissected off the deep surface Vessels may pass from the aneurysm to the skull and are difficult to control Diathermy coagulation bone wax and direct pressure help

Mycotic Aneurysms

These are nearly always caused by bacterial endocarditis which disease was invariably fatal before the discovery of the antibiotics. To-day patients so affected may live to have their aneurysms treated (Goadby 1949) The most usual site for the development of a mycotic aneurysm is adjacent to a coarctation of the aorta or near to the aortic valve and Brock (1952) has resected one of these and replaced it with an artery graft Other sites in decreasing order of frequency are the superior mesenteric cerebral femoral hepatic and splenic arteries Most surgeons (Lambert Rogers, 1951) recommend antibiotics and only treat the aneurysm surgically if it enlarges rapidly or causes symptoms

Traumatic Arterial Spasm

Kinmonth (1952) has investigated the causes of arterial spasm changes in the size of large arteries and the treatment of arterial spasm He believes that traumatic arterial spasm is due to mechanical stimulation of the vessel wall itself In a group of experimental animals various methods for the relief of arterial spasm were investigated including the local application of papaverine procaine caffeine priscol heparin and benzodioxane Papaverine consistently produced relaxation of the artery He recommends that in a case of traumatic arterial spasm the treatment should be as follows the artery should be exposed and the whole area inspected If the artery is found to be in spasm it should be covered with a 2 5 per cent solution of papaverine sulphate for ten to fifteen minutes He has used the method on two patients and in both the arterial spasm relaxed satisfactorily If the vessel remains in spasm he advises suture of the wound with a fine polythene tube down to the artery and at intervals 1 per cent papaverine sulphate should be instilled into the tube until the circulation has been restored The systemic administration of papaverine is without effect (Kinmonth 1951)

Plastics in Peripheral Vascular Surgery

The use of polythene cellophane for the treatment of aortic aneurysm has been described This is a use for an irritant plastic but many plastics are inert in the tissues and these also have a use in vascular surgery A polythene tube is the most satisfactory way of maintaining an intravenous infusion for a long period blood clots much less readily in a polythene than a metal cannula and such an infusion may continue satisfactorily for days or weeks

Hufnagel (1947) has used a leucite tube to replace segments of

the thoracic aorta of dogs with good functional results, and more recently Voorhers (1952) and his colleagues have bridged defects in the aorta of experimental animals with a prosthesis made of Vinyon "N" cloth This latter development is of interest and may prove to be of clinical value They folded the clot longitudinally and stitched it to form a tube of the required diameter and length it was then placed across a gap in the abdominal aorta of a number of dogs Vinyon cloth is a fine mesh material, blood leaks through, but this is soon stopped by the formation of fibrin plugs, so that the cloth tube can conduct the arterial blood flow These cloth tubes become lined by a film of flattened cells similar in appearance to normal intima

THE VENOUS SYSTEM

Phlebography

There are two main methods of demonstrating the peripheral venous system on an X ray film, the orthograde and the retrograde The orthograde or ascending phlebogram is performed by injecting 20 c c of 50 per cent pyelosil into a vein on the dorsum of the foot, a blood pressure cuff is placed above the ankle to obstruct the superficial veins and force the contrast medium into the deep veins A radiograph obtained by this method is of little value because it does not show the state of the valves in the deep veins

A modification of this method of ascending phlebography designed to demonstrate the valves in the deep veins has been suggested by Scott and Roach (1951) and an efficient technique worked out by Cockett (1952) The injection is performed and the blood pressure cuff applied as before but just before the injection has been completed the patient is told to perform the Valsalva manœuvre (forced expiration against a closed mouth and nostrils), this forces the contrast medium back down the veins and the valves are seen in a most convincing manner

The retrograde phlebogram has been used by Bauer (1950) He ties the saphenous vein at the fossa ovalis in the groin and injects the contrast medium into the proximal stump The table is tilted with the feet down to an angle of 45 degrees In the normal patient the contrast medium flows down to the first valve or disappears into the vena cava when the valves are incompetent it flows down to the knee or lower

Interruption of the Deep Veins of the Lower Limbs

In 1950 Bauer reported his results after division of the popliteal vein in 245 patients with evidence of valvular incompetence in the

femoral and popliteal veins To use his own words "A marked improvement was observed in all patients The aching and bursting was relieved almost at once The ulcers generally healed in a shorter time than might have been expected with conservative treatment Walker in the same year analysed a much smaller series of thirty popliteal ligations performed at St Bartholomew's Hospital In his opinion the operation was most satisfactory when bursting pain was a prominent feature He advised measurement of the venous pressure as a valuable aid to the selection of patients likely to benefit from a popliteal vein interruption From a small personal experience of this operation it appears that Walker's conclusions are correct in that deep vein ligation benefits many patients with bursting pain and some patients with ulceration but has little if any effect on œdema

The previous edition of Recent Advances in Surgery contained a report of the work of Allen on interruption of the femoral veins or inferior vena cava as a prophylactic measure against pulmonary embolism The effects of this operation have now been assessed Erb and Schumann (1951) subjected every other patient admitted to their service with a fractured neck of femur to bilateral superficial femoral vein ligation Fifty patients had their veins tied and fifty were used as controls nine (18 per cent) of the patients with ligated veins developed pulmonary emboli and only six (12 per cent) of the controls Only one patient died of a pulmonary embolus and the veins of this patient had been tied Allen (1949) himself reports the following results from the Massachusetts General Hospital of 905 middle aged patients given dicoumarol prophylactically after operation there were no deaths from pulmonary embolism but two died from hæmorrhage Of 1 500 patients subjected to femoral vein ligation seven died from subsequent emboli

Ligature of the inferior vena cava may well be effective in preventing pulmonary infarction but the late sequelæ are crippling Shea and Robertson (1950) report that of thirty seven patients subjected to interruption of the inferior vena cava all had subjective complaints all had some objective changes, such as œdema varicosities or chronic leg ulcers some were able to work, but others were completely disabled They conclude that vena caval ligation should be considered only as a life saving measure and should not be used prophylactically

Gravitational Ulcers

Cockett (1953), amongst many others has studied this problem

He considers that whilst some ulcers are associated with incompetent saphenous veins and many with incompetent deep veins, in a high proportion some additional local cause must exist He bases this opinion on the following observations Many patients with ulcers show no evidence of saphenous valvular incompetence Many patients with long standing varicose veins have no ulcers Saphenous ligation properly performed and combined when necessary with vein stripping fails to cure ulcers in a significant proportion of patients Many patients with ulcers have abnormal deep veins Efficient pressure on the ulcer heals it in a high proportion of cases These

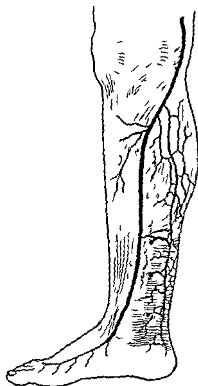
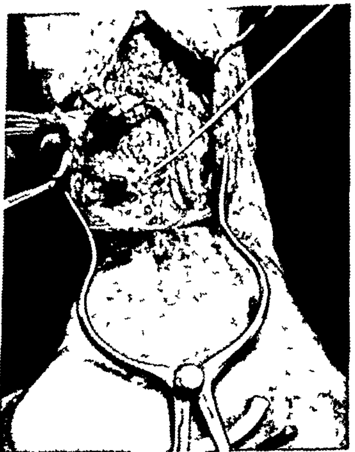


FIG 125 Diagram of the venous drainage of the ulcer bearing area of skin and subcutaneous tissue It is not to the main saphenous vein but to the deep veins *via* a group of perforating veins

ulcers have a constant anatomical position just above the malleoli usually the medial

During a search for a local cause he has made the following observations The venous drainage from the skin above the malleoli is not directly to the saphenous veins it passes *via* a group of perforating veins through the deep fascia to the deep veins in the calf (Fig 125) The skin of this area has a particularly poor arterial blood supply as shown by injecting the arteries with a bismuth suspension in the postmortem room dissecting the skin and sub



Figs 126 and 127 Photographs from an operation showing an incompetent perforating vein in the base of an ulcer The saphenous vein seen lying anteriorly is normal

(Figs 1 & 3 by courtesy Mr ... and the Editor The Lancet

cutaneous tissues from the limb and X raying them The calf muscle pump exerts a considerable effect by pumping blood from the area during activity There is a constant valve on the main communicating vein draining this area of skin just deep to the deep fascia and before it joins the deep veins This last observation is in Cockett's view the key to this problem These incompetent perforating veins can be demonstrated in many ulcer patients, both by phlebograms and during surgical operations (Figs 126 and 127) If these veins are tied (it is usually necessary to excise the ulcer to expose this vein) many ulcers which have failed to respond to saphenous ligation heal satisfactorily

The Injection Treatment of Varicose Veins

The last few years have witnessed a decreased use of this method of treatment Kinmonth and Robertson (1949) have studied the method by injecting pyelosil into normal and varicose veins using techniques similar to the standard therapeutic methods and then X raying the limbs They have found that the fluid injected had a tendency to pool on the valves of the deep veins They recommend that retrograde injection of varices at the time of saphenous ligation should be abandoned that varices should be injected by the empty vein technique with the limb horizontal that the amount injected should not exceed 1 5 ml and that sclerosing agents requiring a larger volume should not be used After the injection the leg should remain at rest for five minutes and then elevated and exercised vigorously to sweep the sclerosing solution into the general circulation where it is made harmless by dilution

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PART VI — THE BREAST

CHAPTER XXII

CARCINOMA

H J B ATKINS

Ætiology

WITHIN the last twenty years advances of a most stimulating kind have been made in our knowledge of the possible causes of breast cancer Unfortunately much of this work has been done on the mouse and how far results achieved in this field of biology will be of value in helping to solve problems of human pathology is unpredictable

Genetic Influence By selective breeding it is possible, in the mouse to produce a strain in which the adult females will almost invariably develop cancer of the breast or alternatively to produce a strain in which breast cancer practically never occurs It might be concluded that this was clear enough evidence of a hereditary factor in the genesis of breast cancer in the mouse, but never were the pitfalls of jumping to conclusions better exemplified Further work has shown that much of this effect is due to the transmission of a factor from mother to daughter in the maternal milk an influence which will be discussed more fully below and one which is in no sense genetic If we subtract this transmissible influence does a truly hereditary factor remain ? Is there anything, that is in the genes of the mother which makes the daughter more susceptible to cancer of the breast ? The difficulties of separating these two influences (if there be two) even in an animal so suitable for such experiments as the mouse are considerable but it would appear that there is indeed a genetic constitution which determines susceptibility to breast cancer and that breast cancer is a truly hereditary disease apart altogether from the milk factor The nature of this genetic influence is now the subject of busy scrutiny and it would appear that it may consist of a constitutional response to hormonal influences which renders the possessor more, or less liable to breast cancer

When we turn to the human two difficulties confront us The first concerns the question as to whether breast cancer is in the

human, a family affair at all and secondly if it be so, whether there are two factors involved a constitutional or genetic one and an extraneous or transmissible one

The fact that there should be any argument over the possibility that cancer of the breast in humans tends to run in families supposes that this tendency if it exists is not a very strong one and requires careful statistical analysis on a large scale to reveal it Of course cancer of the breast is so common that the operation of chance would be bound to reveal isolated instances where many members of many generations of a particular family have suffered from this disease instances so striking as to bias the observer in favour of the possibility of a hereditary influence whatever the evidence and the citation of such peculiar incidents can have little bearing on the problem and may only confuse the issue There is, in fact some conflict of evidence on the matter but it would appear that the relatives of patients with cancer of the breast suffer themselves from cancer of the breast slightly more frequently than would be expected if they had no special predisposition In other words there is probably a slight tendency for cancer of the breast to run in families

Even if this be true we are in no position to say how far this effect is genetic and how far transmissible or whether in the human a transmissible factor exists at all a problem to which we will return later

Hormonal Influence Ever since it was shown on the one hand, that cancer of the breast could be prevented in female mice by castration at an early age and on the other hand, that it could be caused in male mice by the administration of œstrogens, the importance of *hormones in the genesis of breast* cancer has been appreciated No purpose can be served in retailing here the story of endocrine influences in the genesis of breast cancer in the mouse This branch of experimental pathology is not a recent advance and whereas the relation of œstrogens to cancer is an established fact the nature of this relation is as yet imperfectly understood

When we turn to the human the situation is as always more obscure The observer once more finds it difficult to free himself *ab initio* from a bias in favour of the proposition that there is a relation between hormones and cancer of the breast This bias is fortified by the fact that this relation can be proved in the mouse that hormones *can in certain cases* cause cancers of the breast to regress and by inference that other hormones may cause such cancers to flourish and finally that striking isolated instances can be culled from the literature where this relation is exemplified in a

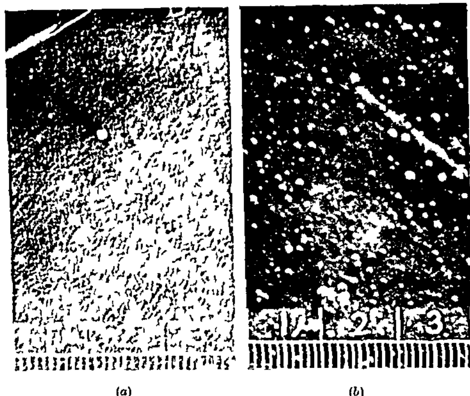
highly suggestive manner the most formidable being the appearance of bilateral cancer of the breast in a male treated by œstrogens for carcinoma of the prostrate Each of these pieces of evidence contains a flaw but it would be mulish to disregard a number of signposts however dilapidated all pointing in the same direction and with all due scientific reservation we may say that it is highly probable that hormones play a part in the development of cancer of the breast in the human perhaps by developing the glandular tissue perhaps by rendering this tissue more susceptible to some other influence perhaps by both

The Transmissible Factor Bittner (1937) has shown that by removing a litter of mice from their mother at birth and suckling them at the breasts of a foster mother the incidence of cancer of the breast in this litter when it grows up approximates to that of the strain of the foster mother rather than to that of the mother Thus the litter from a strain showing a high incidence of breast cancer could be protected by suckling from a foster mother of a strain with a low incidence of breast cancer Conversely the litter of a strain with a low incidence of breast cancer could be given cancer by suckling from a foster mother of a strain with a high incidence of breast cancer This work which has been repeated in laboratories all over the world has led to the important conception of a milk factor which is responsible for the development of cancer of the breast in the mouse This milk factor has been pursued with relentless vigour and its chemical physical and biological properties are beginning to emerge In all these it would do for a virus and even its photograph under the electron microscope is a passable likeness That it can be recovered from tumour tissue and is found in the semen of a susceptible strain renders the original term milk factor inappropriate and it were better termed the transmissible factor or even as it has been by certain workers with a familiarity far from contemptuous simply the factor

Our interest is focused principally around the question as to whether this factor operates in the genesis of *human* breast cancer Examination of this problem the elucidation of which is fraught with such vital consequences whatever the answer is proceeding along these lines —

(i) Electron microscopic studies of human breast milk (Gross L, McCarty K S Gessler A E (1952)) reveal particles similar to those occurring in the milk of susceptible mice These particles are freely distributed throughout the milk of most humans so examined Occasionally they are absent and in such cases there is

no history of breast cancer amongst the near relatives Since they have never been reported as being absent except in those instances when no near relative has suffered from cancer of the breast, and since in many cases when the family history is strong the milk is unduly full of these particles they may indeed be connected with the genesis of human breast cancer (Fig 128) Supposing that by



(a) (b)

Fig 128 (a) Sample of milk from a woman with a family record negative for any malignant tumours for two generations (b) Sample of milk from a woman whose mother had cancer of the breast

[From Gross L McCarty K S and Gessler A E Ann New York Acad of Sci

some means it were possible to prove that these particles in human milk are particles of the transmissible factor we are still far from answering the question as to whether breast feeding has any relation to the genesis of human breast cancer because these particles may be transmitted as well through the placenta during the natural fondling of an infant or by other means

(ii) To determine whether breast feeding has any effect on the subsequent development of breast cancer, efforts have been made to trace back the nursing history of patients with cancer of the breast to see whether the proportion of those who have never

received human milk is the same as in the general population. If this could be shown to be the case then breast feeding could have no effect on the production of this form of cancer. The difficulties of being certain however whether any particular patient has or has not received human milk forty or fifty years before are so great even when the mother is still living to testify on this matter, that little reliance can be placed on results obtained by such a method.

(iii) An alternative is to accumulate a panel of female children who have never received human milk and to see whether the incidence of cancer of the breast is in them different from that in the general population. This investigation is being carried out and with the help of the Society of Medical Officers of Health such a panel is being collected. An enquiry is being made into the early health history of these children in order to determine the effect of breast feeding in protecting an infant from the menace of virus infection during the early years. In addition, by means of a direct follow up by eventual reference to the Cancer Registry and by ultimate resort to the death certificate it will be possible to determine the rate of incidence of cancer of the breast in these persons with a sufficient degree of accuracy to compare this with the rate in the general population.

Until more certain evidence is forthcoming and considering the many proven benefits to both mother and child of breast feeding this should be actively encouraged as it is known to protect the mother to some extent from cancer whatever the unknown effect in this respect may be on the child.

Pathology

Much recent work has been conducted on the rate and direction of spread of cancer of the breast. In regard to the rate of spread endeavours have been made to grade tumours by histological means into those which may be expected to spread quickly and those which are likely to pursue a more leisurely course. A contribution to this attempt has been made by Bloom (1950) but it is perhaps too early yet to say whether the histological criteria adopted in this system of grading will turn out to be the best for determining this point.

A contribution of fundamental importance is that of R. S. Handley (1952*a*) who has investigated the spread of cancers of the breast to the chain of glands along the internal mammary artery. In 119 operable cases in which the internal mammary chain was examined for involvement the distribution of glandular metastases was as shown (Table IX).

TABLE IX.—*Invasion of Internal Mammary Lymph Nodes. Analysis of 119 Cases*

	Site of primary growth		
	Inner half of breast	Outer half of breast	Total
Total number of cases	45 (38%)	74 (62%)	119
All nodes free	10 (9%)	28 (24%)	38 (33%)
Axillary nodes only invaded	8 (7%)	32 (27%)	40 (34%)
Internal mammary nodes only invaded	3 (3%)	1 (1%)	4 (3%)
Both axillary and internal mammary nodes invaded	24 (20%)	13 (10%)	37 (31%)

From R. S. Handley (1952).

This means that the method by which these cases were treated, namely by radical mastectomy, was pathologically inadequate in a third of their number. By the ordinary techniques of operation for breast cancer therefore the result is doomed to failure in a third of the cases because of spread to the internal mammary chain, which is outside the range of tissue extirpated, and the proportion is even higher in growths of the medial half of the breast. Nor can deep X-ray therapy altogether make up for this defect, because Handley (1952*b*) has demonstrated viable cancer cells in these glands after they have been subjected to rigorous irradiation. Nevertheless the discovery of viable cancer cells in tissue which has been irradiated does not mean that the treatment has been valueless, since a cell may still be viable but its malignant properties may have been exorcized or severely crippled.

This work, however, must profoundly modify our views as to treatment, particularly perhaps in growths of the inner half of the breast, and it will be necessary now to examine how far these pathological concepts fit in with and influence modern views of therapy.

Treatment

Value in Prolonging Life. The surgical world was startled not so long ago, by a statistical survey contending that radical mastectomy does little or nothing to increase the expectancy of life of patients suffering from carcinoma of the breast (Park, W. W. and Lees, J. C. 1951). Doll (1952) in an authoritative statistical evaluation of this view maintains, however, that the figures produced do not substantiate such a contention. Nevertheless the effect of the very suggestion has been to destroy any complacent

satisfaction which we may have had for existing methods Such an unduly pessimistic outlook is perhaps, a reflection of the significance of the pathological advances outlined above and it is interesting to see how those concerned with the treatment of cancer of the breast have reacted to this atmosphere

Modern Trends It is possible to discern two distinct and contradictory trends the one which seems to argue that cancer of the breast is in general incurable, and that the best that we can do is to arrest its progress until finally its relentless advance overwhelms the patient or she succumbs in the meanwhile to some other malady the other argues that these fresh pathological discoveries are a challenge to the surgeon who must devise yet more radical procedures to remove these recently explored paths of spread

The first school is represented by McWhirter (1948) who since 1941 has treated nearly every early carcinoma of the breast occurring in the South Eastern region of Scotland by one method namely simple mastectomy followed by irradiation of the glandular fields A comparison of the results in this series with others published elsewhere in which radical mastectomy has been performed where practicable can never be exact because the staging of cases in which the glands have not been removed is not subject to the stern corrective of histological examination of the axillary field and in neither series is the state of the internal mammary glands known This loophole provides scope for endless discussion and juggling with figures so that the truth if there be such a thing is difficult to come by When however we realize that it is possible to put forward figures purporting to uphold the view that the results of treatment in terms of life expectancy by orthodox surgical methods do not differ substantially from the results of withholding treatment it is easy to understand how a comparison of the results of two methods of treatment differing but little in their efficacy can be most confusing Even though complete reliance may be placed upon the absolute integrity of the investigator the greatest reserve must be maintained in accepting statistical evidence on such matters when the results appear to be contradictory to common experience Whereas the figures may hold together statistically the observations upon which they are based may be open to wide interpretation For instance the diagnosis of Stage I cancer of the breast depends in many cases simply on the opinion of the histologist examining the section and the criteria for diagnosis of cancer differ materially from school to school

It may be that one of the reasons why the results of treatment by McWhirter s method compare not unfavourably with the results

of treatment by radical mastectomy is because, as we shall see, most series treated by the latter method have in the past been compounded of cases that were unsuitable for radical mastectomy in the first place and in which the operation did harm together with those in which radical mastectomy was proper and in which the prognosis is excellent

At the other extreme, Urban (1952) has devised an operation whereby the internal mammary chain is removed as part of the radical mastectomy specimen He excises half the sternum, with its attached costal cartilages together with the internal mammary artery and its satellite lymph nodes The defect in the chest wall is made up with a fascia lata graft and the whole area is covered by swinging the opposite breast over as a pedicle flap This formidable operation takes five to six hours and although only 1 case out of the first 40 has been lost in the immediate post operative period one feels inclined to wait with watchful interest before passing judgment on a procedure so radical Some following the same line of reasoning have extended their operative field in other directions Wangensteen (1952) makes excursions into the supraclavicular triangle and others remove both breasts It cannot be claimed that many of these measures are recent or that they will turn out to be advances, but they are cited to illustrate the stimulus which our dissatisfaction with present methods affords

How then is the neutral observer to proceed? As in so many problems where life is at stake and until one extreme or the other can be shown to hold the advantage, it would be wise to keep to the middle path Even so the automatic prescription of radical mastectomy for early cancer of the breast is not as we now appreciate the best that we can do and in regard to this problem an eclectic attitude may be enjoined A most thoughtful exponent of this school is Waldron Smithers (1952) who breathes new vigour into the hackneyed expression that *each case must be judged on its merits* His view is that surgery is more effective in eradicating breast cancer than radiotherapy but unsuccessful surgery may make matters worse whereas radiotherapy generally provides some improvement and may lead to tumour regression for many years

This principle if we consider the primary growth and the glandular field as separate entities may be applied in many ways —

(i) A patient with a small tumour in the outer half of the breast and with no more than one or two palpable and mobile axillary glands should have a radical mastectomy post operative irradiation being given if careful examination of the specimen indicates that local recurrence is likely

(ii) A patient with a small mobile tumour in the lateral half of the breast but who has many axillary glands involved particularly if these are in the apex of the axilla should be treated by local mastectomy and post operative irradiation to the glandular fields

(iii) A patient with a short history and a substantial lump in the medial half of the breast with enlarged glands in the axilla implying a rapidly growing cancer and involvement of the internal mammary chain is best treated by radiotherapy alone

The possible permutations and combinations of clinical presentation are too varied to allow a discussion of each but the above are good examples of how this principle works in practice, and there we may indeed we must, leave the matter In this problem all that we can do is to keep an open mind and follow for the time being that practice which having regard to the available evidence seems the most sensible

Hormones The treatment of advanced cancer of the breast by hormones is in a small proportion of cases, so successful that no patient should be allowed to die from the effects of mammary cancer without a trial of this form of therapy It is not on the other hand sufficiently established to be indicated where other methods of treatment of proven efficacy are appropriate unless in conjunction with these

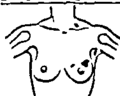
Both androgens and œstrogens cause a regression of these cancers in certain cases and their mode of action being unknown their prescription is empirical The effect of these substances on the growth can be detected histologically and clinically The former effect has not been fully investigated but the latter is there for all eyes to see and if we are to compare the effect of one hormone with another if we are to determine the best dosage of a particular hormone or if we are to assess the susceptibility of a particular manifestation of cancer to a hormone it is most desirable to be able to express clinical improvement numerically

The Mean Clinical Value No method of numerical assessment can be more than an approximation and it must be interpreted with this qualification in mind but the most successful is that devised by Walpole and Paterson (1949) whereby the progress of each lesion is assessed separately and if it is improving it is assigned 2 marks if stationary 1 and if deteriorating 0 the appearance of a new lesion also being given 0 The average is taken by dividing the sum of these marks by the number of lesions and the whole is brought to a wieldy number by multiplying this average by 6 Fig 129 illustrates the application of this principle

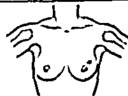
Thus it will be seen that a patient who is responding well receives

ASSESSMENT OF MEAN CLINICAL VALUE

BEFORE TREATMENT



DURING TREATMENT



LESIONS	LESIONS
1 L BREAST	1 L BREAST-IMPROVED (2)
2 L AXILLA	2 L AXILLA- " (2)
3 L SUPRACLAVICULAR	3 L SUPRACLAV - UNALTERED (1)
4 SKIN NODULE	4 A NEW SKIN NODULE (O)

(THE APPEARANCE OF A NEW LESION IS MARKED O)

$$MCV = \frac{\text{TOTAL MARKS}}{\text{NO OF LESIONS}} \left\{\begin{array}{l}\text{AVERAGE}\\ \text{MARK}\end{array}\right\} \times 6 \left[\begin{array}{l}\text{TO BRING IT}\\ \text{TO SUITABLE}\\ \text{NUMBER}\end{array}\right]$$

IN ABOVE CASE -

$$MCV = \frac{2+2+1+0}{4} \times 6 = 7 5$$

MAXIMUM = 12
NO EFFECT = 6
MINIMUM = O

Fig 129 See text

MEAN CLINICAL VALUES

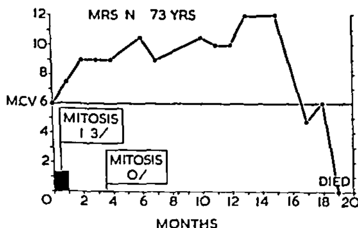


Fig 130 See text

the maximum of 12 marks one who is deteriorating rapidly 0 and one who is stationary 6 The difficulties of mensuration make this assessment *only an approximate one but experience* with the method persuades the observer that it is of unexpected value in practice To put it bluntly a patient who maintains an M C V of

9, month after month is one who would be described as "responding well to treatment but in whom there is not a complete and ubiquitous regression of the cancerous manifestations a long sentence and one nicely epitomized by the expression 'M C V = 9

The value of having a numerical expression of clinical behaviour can be seen in Fig 130 which shows the progress of a patient under œstrogen therapy and in Table X where the results of treatment of 42 cases under œstrogen therapy expressed as the average M C V are tabulated in a way which puts a value on this form of therapy at sight Furthermore for the purpose of relating graphically for instance clinical response to mitotic cell counts and other more abstruse scientific investigations such a numerical value is a necessity

Indications It has been observed in general that patients well past the menopause with soft tissue lesions respond best to œstrogens and young patients with bony metastases respond best to androgens but there are so many exceptions to this rule both of a disappointing and of an unexpectedly satisfactory nature that no laws can be laid down and while it is customary to exploit this observation in choosing the hormone to be administered in the first instance much more work is necessary before we can formulate more exact rules For patients who fall into neither of the above categories the prognosis in regard to hormone therapy is not so good but this treatment is nevertheless worth a trial in cases too far advanced for other forms of therapy and it would be a hollow sham to pretend that in such cases the choice of hormone for trial is more rational than by the spin of a coin

Dosage and Toxic Effects We are as yet uncertain as to the optimum dosage of œstrogen in these cases Most workers give 15 mg of stilbœstrol daily for the rest of the patient's life but smaller doses may prove to be nearly as effective and some centres claim slightly more satisfactory results and no more toxic manifestations with doses up to 500 mg daily It is in determining such points that the M C V system universally adopted will prove of much value

Toxic manifestations are nausea and vomiting œdema of the extremities uterine bleeding and hypercalcæmia Evidence of such may demand a reduction in the dose or a change to a different preparation of which dienoestrol (a quarter as potent weight for weight as stilbœstrol) and ethinyl œstradiol (twenty times as potent as stilbœstrol) are useful preparations

Androgens are prescribed as testosterone propionate 50 mg three times weekly by intramuscular injection or more expensively

as methyl testosterone by mouth in doses up to 100 mg daily. Symptoms of virilism or acne may demand that the dose should be reduced.

Results. The results of treatment with oestrogens in an unselected group of 42 patients with soft tissue lesions treated since the application of the M.C.V. principle are set out in Table X. These

TABLE X

OESTROGEN THERAPY

(42 CASES)

MCV	12-8	7-4	3-0	UNABLE TO TAKE DRUG
OVER 60	9	4	6	6
UNDER 60	4	5	5	3
TOTAL	13	9	11	9

results are in accord with those of most observers and with our previous observations before the introduction of this system and we may conclude that just under a quarter of such patients are unable to tolerate the drug in any form, in a similar proportion the drug is useless, in about a quarter some delaying effect is observed, and in nearly a third the improvement is striking. If oestrogens are going to work the patient will show some response within eight weeks and it is therefore fruitless to prolong treatment beyond that time if it is doing no good. In those patients who respond, the duration of satisfactory response is usually a little over a year, and a typical course is shown in Fig. 130. Sometimes however this effect may be prolonged indefinitely and Fig. 131 shows a patient whose treatment began in 1949 and who is perfectly well four years later without any clinical evidence of extension.

The results of androgen treatment are more difficult to assess because the effects are largely subjective. In the majority of patients with widespread bony metastases there is an improvement in a sense of well being and a relief of pain; in a small proportion too there is clinical and radiological evidence of regression of the bone secondaries which undergo recalcification. Unfortunately

these effects are usually short lived and, whether it be because this hormone has a less prolonged effect than œstrogens or because the younger patients with skeletal metastases in whom these preparations are usually employed tend naturally to progress more rapidly, androgens have not the same reputation as œstrogens for sustained benefit

Finally we may remark that the bald narration of the effect of these preparations disguises a tale the unfolding of which may in



Fig 131 The effect of œstrogen therapy on advanced cancer of the breast

the future lead to startling advances in our knowledge of cancer as a whole For the first time in history the prescription of substances natural to the body and of relatively low toxicity has been shown to modify the behaviour of malignant growth With our present weapons surgery and radiotherapy we may do so much and as these are all or nearly all that we possess we struggle to apply them in the most effective way It would seem however that the limits of their value may have been reached and researchers are turning increasingly to the investigation of other weapons claiming for their field of scrutiny that ancient association of the soil and the seed We wish in fact to know how the hormones modify the

environment so as to nourish [illegible] [illegible] the [illegible] parasite we wish to identify, pin down and crush at the extrinsic factor if there be such so that ideally this treacherous spawn may be destroyed

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EDWARDS R.A. SURG

PART VII—THE ENDOCRINE GLANDS

CHAPTER XXIII

THE THYMUS

GEOFFREY L KEYNES

THYMECTOMY FOR MYASTHENIA GRAVIS

CURRENT interest in the surgery of the thymus gland received its first stimulus from the work of Blalock at Baltimore He had successfully removed a thymic neoplasm from a myasthenic patient in 1936 and in 1941 reported on the effect of the removal of apparently normal thymus glands from six myasthenic patients Most of these patients had appeared to benefit and it was on this basis that the writer performed the first thymectomy done in Great Britain in 1942, at New End Hospital Hampstead The patient was a woman of thirty two in an advanced state of myasthenia gravis and it was believed that she would soon die if nothing was done to help her The operation proved successful the patient making a complete recovery from the symptoms of myasthenia and she has now remained free of symptoms for over ten years Encouraged by this remarkable result in an apparently moribund patient the writer has operated on 250 myasthenic patients during the last ten years and several other operators have followed suit so that the number of thymectomies performed in Great Britain since 1942 must number well over 300 Extended experience has shown that 65 per cent of myasthenic patients (apart from those with thymic neoplasms) can be quite or almost quite relieved of their symptoms by thymectomy a fact which seems to justify the inclusion of thymectomy among the recent advances in surgery Previously the symptoms of myasthenia could be palliated by the use of neostigmin (prostigmine) but otherwise the patients could only be offered the rather remote chance of a spontaneous remission Such remissions certainly do occur but they usually last only a short time if the symptoms have been pronounced and the general rule is slow progression with increasing disability often ending in death from respiratory infections It must be emphasized that in the writer s experience favourable results from thymectomy are only to be expected in those patients who did not have any kind of

neoplasm in their thymus glands It has been found that about 12 per cent of patients with myasthenia gravis have a neoplasm or thymoma" in the anterior mediastinum and that *primary* removal of these tumours has given exceedingly bad results, nearly all the patients having died within a short time from severe relapse of symptoms sometimes with respiratory paralysis Very much better results have been obtained by first exposing the tumours to irradiation with high voltage X rays the thymectomy being done two or three months later when the skin reaction has subsided It is of great importance therefore, to diagnose the presence of a



FIG 132 True lateral view of anterior mediastinum with shadow of thymoma before irradiation and similar view afterwards showing reduction in size of tumour

thymoma before any operation is undertaken and this can usually be done by careful X ray examination of the anterior mediastinum, assisted by tomography The true lateral view of the mediastinum is more likely to show the tumour than the antero posterior view in which the tumour will only be seen if it is large enough to overlap the shadow of the ascending aorta and pericardium Thymomas commonly lie on the upper part of the pericardium and the root of the aorta and become closely adherent to the adjacent pleural and pericardial membranes Their removal is usually possible unless the root of the lung has been enveloped by the growth The pathology of these tumours is still doubtful but they certainly present most of the features of malignancy though they seldom or

never metastasize to lymph nodes, nor to other parts of the body by the blood stream

The surgery of the thymus is mainly concerned therefore with the extirpation of the apparently normal gland It has no known normal function and its removal even from young children has not been found to produce any undesirable side effects As age advances the gland becomes more and more fatty but a considerable amount of the characteristic lymphoid tissue with epithelial elements in the shape of reticular cells and Hassell s corpuscles (both from the third branchial complex) can still be found up to and even

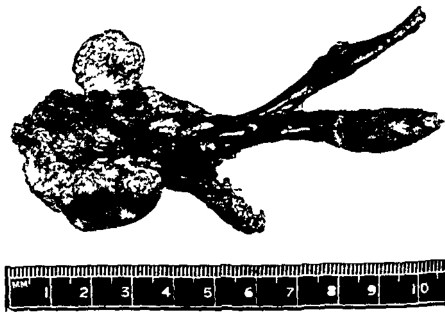


FIG 133 Thymus gland removed at operation with a thymoma at the lower end (on left of picture)

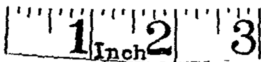
after the age of fifty Most thymus glands from myasthenic patients also show conspicuous 'germinal centres' though the meaning of this particular form of hyperplasia is quite unknown

The selection of patients for thymectomy is not easy though it is quite plain that there can be no such thing as an 'emergency operation for a patient with myasthenia gravis If the disease is in an acute phase the operation will almost certainly be fatal The symptoms tend to vary in severity and a remission must be awaited before the operation is seriously considered At the other end of the scale are those patients whose symptoms are mild so that they can manage to exist in reasonable comfort with the help

of neostigmin Operation for them is clearly not urgent, but myasthenia gravis tends to be on the whole a slowly progressive disease so that there are good reasons for carrying out the treatment while the risk of post operative death is virtually nil—in addition to the fact that the results become somewhat less good the longer the disease has been established The most obviously suitable patient is the one with moderately severe symptoms of myasthenia and a history of not more than five years Among such patients a high proportion of good results is to be expected with a very low rate of mortality and morbidity Results are nevertheless erratic and every patient must be warned that no improvement can be guaranteed Very few however will be deterred by this warning their lives even with the help of neostigmin, being so miserable that they will face anything offering a good chance of recovery Myasthenia gravis occurs at all ages from infancy to old age but most patients come within the limits of fifteen to forty Age does not seem materially to affect the results except in so far as the older patients are likely to have had the disease longer and are more liable to post operative complications, such as respiratory infections

The anatomy of the thymus gland is unfamiliar to most students, since it disintegrates soon after death and is usually not identifiable in dissecting room bodies Also the bodies are usually those of elderly subjects in whom the gland is likely to have been largely replaced by fat Nevertheless the thymus does not atrophy so soon as has been commonly supposed It is a solid bilobed structure easily identifiable up to the age of forty or over By the age of fifty it is certainly much reduced, though even then it can still be dissected out with precision and removed in its entirety Each lobe is elongated with a slender cornu extending up in the neck to the thyroid isthmus and with a thick body lying in front of the inferior thyroid veins the left innominate vein and the aorta to end on the upper part of the pericardium Each body is covered by the pleura of its own side and so is in close proximity to the lung The thymus is supplied by two or three fine branches on each side from the internal mammary arteries, and is drained posteriorly by two veins which commonly unite to form the large thymic vein emptying directly into the left innominate vessel The thymus gland thus lies medially behind the manubrium and body of the sternum and is best approached by splitting the sternum down the centre line The skin incision is T shaped the horizontal limb being a short collar incision just above the suprasternal notch and the vertical limb extending in the midline almost to the

xiphisternum When the pretracheal muscles have been separated just above the sternum a finger is introduced into the anterior mediastinum in order to clear the space behind the bone The sternum may conveniently be split by sawing through the outer table with a Hey's saw and then by cutting with a Sauerbruch's sternum splitter If the division be carried almost to the lower end of the bone the two halves can be forced apart by introducing a strong self retaining retractor so giving free access to the whole of the anterior mediastinum Loose connective tissue is divided





Weight 9 5 grams

FIG 134 Typical thymus gland removed at operation (upper cornua on left)

in the midline to expose the capsule of the thymus gland and the pleural membrane is carefully peeled off the surface of each lobe great care being used to avoid puncturing the pleura Each cornu is followed up into the neck and the lower part of each body which usually spreads out in a thin sheet, is detached from the pericardium All vessels are divided and ligatured and the gland is removed It usually weighs 12–15 gm but varies greatly in size and may weigh as much as 30 gm or even more The size seems to have little relation to the severity of the disease When the gland has been removed the mediastinum is closed without drainage The edges of the two halves of the sternum can be accurately approximated by

lifting the patient's shoulders forward and are sutured with a few knots of strong catgut passing through the edges of the bone, which have been drilled with a slender bradawl The muscles and periosteum are sutured over these knots the subcutaneous fat and skin being closed in two layers Dressings are applied in such a way as not to interfere at all with respiratory movements Before the operation the patient should have been receiving neostigmin by the mouth up to the limit of toleration At the conclusion of the operation an intramuscular injection of neostigmin is given if the symptoms of myasthenia were severe, so that there may be no weakening of the respiratory movements or cough reflex The anaesthetic should be designed to avoid all irritation of the trachea, and an endotracheal tube is therefore undesirable After pentothal induction, cyclopropane and oxygen is given through an accurately fitting mask and a large airway so that the movements of the lungs can be completely controlled Should the pleura be accidentally punctured during the operation the lung can be kept inflated and a post operative pneumothorax perhaps avoided Should this develop it is usually best to allow the lung to expand spontaneously though, if there is fluid in the pleura as well, aspiration should be done as often as may be necessary This complication usually does not arise but it can be dangerous if accompanied by any degree of bronchitis or pneumonitis Penicillin and increased dosage of neostigmin must then be given, the latter being taken by the mouth as soon as the patient is able to swallow The myasthenic patient is liable to react to any disturbance by becoming more myasthenic and the symptoms are always accentuated by any infection, even if it be only an ordinary cold In many instances the patients seem to be almost completely unaffected by the operation, in others the reaction may be so severe that complete respiratory paralysis follows One patient was only kept alive for two spells each of several hours during the immediate post operative period, by being put in an iron lung though she was destined within a few weeks to become completely symptom free and to abandon the use of neostigmin

Myasthenia gravis is an exceedingly erratic disease in its manifestations its course and its response to treatment This characteristic has discouraged some operators from pursuing thymectomy as a form of treatment because they disliked the impossibility of predicting what the result would be It has even led to so pessimistic an attitude in some American writers that statements have been made to the effect that operation does not influence the course of the disease, and even that the thymus gland

xiphisternum When the pretracheal muscles have been separated just above the sternum a finger is introduced into the anterior mediastinum in order to clear the space behind the bone The sternum may conveniently be split by sawing through the outer table with a Hey s saw and then by cutting with a Sauerbruch s sternum splitter If the division be carried almost to the lower end of the bone the two halves can be forced apart by introducing a strong self retaining retractor so giving free access to the whole of the anterior mediastinum Loose connective tissue is divided





Weight 9.5 grams

FIG 134 Typical thymus gland removed at operation (upper cornua on left)

in the midline to expose the capsule of the thymus gland and the pleural membrane is carefully peeled off the surface of each lobe, great care being used to avoid puncturing the pleura Each cornu is followed up into the neck and the lower part of each body, which usually spreads out in a thin sheet is detached from the pericardium All vessels are divided and ligatured and the gland is removed It usually weighs 12–15 gm but varies greatly in size and may weigh as much as 30 gm or even more The size seems to have little relation to the severity of the disease When the gland has been removed the mediastinum is closed without drainage The edges of the two halves of the sternum can be accurately approximated by

already mentioned Attention should instead be focused on the many sufferers from myasthenia gravis who have no obvious gross disease in the thymus but most of whom will nevertheless benefit by surgical extirpation of the thymus gland

The status of the thymus as an endocrine gland has been recently confirmed by the researches of Professor Andrew Wilson of Liverpool University He has succeeded in preparing an active extract of thymus glands removed from myasthenic patients which is capable of consistently damping down the contractions of a muscle nerve preparation in a degree comparable with the effect of tubocurarine chloride The potency of the extract is found to be closely correlated with the clinical effect of the removal of the glands extracted The operation of thymectomy is thus given a biochemical basis in addition to that provided by clinical observation of results

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For details of technique see Techniques in British Surgery ed Maingot 1950 London W B Saunders Co p 126

is not really concerned in its production It is difficult to understand how this view can be maintained in view of the consistently favourable results that have been obtained in this country All the patients operated on have been carefully reviewed at intervals Although improvement after operation may be rapid or very gradual, the fact remains that 90 per cent of the patients do improve Of these 90 over 30 are apparently cured and have remained free from symptoms for periods up to more than ten years Another 30 or more are so much better that they are able to lead normal lives, and can return to their former occupations The remaining 25 per cent are better, but still need the help of a considerable amount of neostigmin and are liable to relapse whenever they have any infective illness Of the 10 per cent who are not improved at all, some have probably been misdiagnosed some forms of myopathy being very difficult to distinguish from myasthenia gravis This favourable view of the effect of thymectomy upon myasthenia gravis has been subjected to close scrutiny by physicians interested in the problem and the results in 100 unselected patients have been statistically analysed by Dr R T Ross working at the National Hospital for Nervous Diseases Queen Square The average period that had elapsed since operation was four and a half years and it was found that 87 patients had benefited from the treatment Of these 41 appeared to be quite cured and 26 had only inconstant and minor symptoms of myasthenia *An excellent result could therefore be claimed in* 67 of the 100 patients examined No comparable results have ever been obtained in any series of patients treated medically

It must be again emphasized that these figures do not include any patients who had a thymoma in association with myasthenia The presence of a neoplasm has been regarded as a different problem demanding a different approach and has been found to indicate an exceedingly bad prognosis The disease is often more rapid in its onset and severe in its manifestations Primary operation as already stated has been found almost useless but removal has been more successful after preliminary radiotherapy The removal of a thymoma is often a much more difficult operation than an ordinary thymectomy and introduces greater hazards since it may be impossible to avoid opening one or both pleural cavities The presence of a thymoma stimulates the formation of dense fibrous tissue in its neighbourhood with adhesions to neighbouring structures so that its removal may sometimes prove to be impossible It is possible that *selection of patients with thymomas for operation* with the many inevitable failures has produced the pessimistic view

depressed The localized area of increased activity can be discovered by scanning the patient's neck with a directional Geiger Muller counter after a dose of radioiodine and the treatment consists of the surgical enucleation of the offending hot nodule

Other Indications for Surgery When a hyperthyroid patient under treatment with thiouracil develops agranulocytosis the drug is stopped massive doses of penicillin are given and one or more transfusions of fresh blood As soon as the granulocytes regain their normal level, a course of Lugol's iodine is given and thyroidectomy carried out

Occasionally a toxic goitre is so large that it is an embarrassment to the patient and pressure on the trachea makes it necessary for her to sleep propped up with pillows Although thiouracil may render such a gland non toxic thyroidectomy is called for on mechanical grounds For like reasons a retro sternal goitre will require removal

Finally when a patient who lives far removed from medical care develops hyperthyroidism, it is advisable to proceed to thyroidectomy after suitable preparation It is unsafe to carry out long term thiouracil therapy in such a person for agranulocytosis can occur at any time and on any dosage and such a complication then makes hospital treatment an urgent necessity

Thyroidectomy In carefully prepared patients this operation is now safe and the mortality is a fraction of 1 per cent The superior thyroid vessels and middle thyroid veins are divided, the inferior thyroid arteries ligated in continuity and about seven eighths of each lobe removed The recurrence rate of hyperthyroidism after this form of subtotal thyroidectomy is very low Identification of the recurrent laryngeal nerves at operation reduces the number of paralysed vocal cords to less than 1 per cent, and the careful preservation of at least one parathyroid prevents post operative tetany

Preparation for operation is conveniently planned by giving methyl thiouracil 0 2 gm and 1 thyroxine 0 1 mgm three times a day for six weeks and continuing if necessary with half this dose of methyl thiouracil until the patient is euthyroid (i e of normal thyroid function) If the gland feels soft it can be further prepared by giving 5 minims Lugol's iodine three times a day in the two weeks before operation and it is unnecessary and undesirable to stop giving the thiouracil at the same time Lugol's solution has no special merit for all forms of iodine are equally effective a daily pill containing 3 grains of potassium iodide will provide more than the patient's requirements Excellent preparation is also afforded

CHAPTER XXIV

THE THYROID AND PARATHYROIDS

SELWYN TAYLOR

HYPERTHYROIDISM

The opening of the atomic pile at Harwell has ensured a regular and inexpensive supply of radioactive iodine in England so that there now exist three alternative methods of controlling hyperthyroidism subtotal thyroidectomy, prolonged treatment with thiouracil, and therapy with radioiodine The indications for using these different forms of treatment are now emerging, together with much new knowledge about the physiology and pathology of the thyroid

Indications for Surgery in Hyperthyroidism

Toxic Nodular Goitre Means of Boston has stressed how helpful it is to distinguish between hyperthyroidism occurring in the diffusely enlarged thyroid (Graves' disease) and that associated with a nodular gland Toxic nodular goitre occurs typically in an older age group The patient has usually harboured an enlarged thyroid for many years and the onset of symptoms is often insidious Eye changes are frequently absent and there may be no nervousness The brunt of the toxic changes falls on the heart and the patient may present with auricular fibrillation and heart failure

The presence of a toxic nodular goitre is an absolute indication for thyroidectomy if the patient is fit enough or can be made so for operation The reason is that this form of hyperthyroidism is much more resistant to thiouracil and radioiodine than is Graves disease Thiouracil is useful for pre operative preparation as described below but has to be given in full doses and for a long time and such a dosage would be unsuitable for indefinitely prolonged therapy

Cope has drawn attention to the solitary toxic nodule a condition first described by Plummer but the existence of which has only recently been confirmed by radioiodine studies When a single nodule in the gland is hyperactive (the 'hot nodule of American authors) the function of the remainder of the thyroid tissue is usually

Indications for Radioiodine in Hyperthyroidism

There are many radioactive isotopes of stable iodine but the one in almost universal use to day is ^{131}I It is prepared in this country by the neutron irradiation of metallic tellurium in the chain reacting pile at Harwell ^{131}I has been chosen because it gives off the larger part of its energy in β rays and only a small part as γ rays The β rays exert intense ionization on the tissues but have a range of only a few millimetres and since this isotope is concentrated by the thyroid in the same way as stable iodine it is possible to subject the gland to far greater doses of irradiation than can be administered by external irradiation (X ray therapy or radium) which must traverse the skin The rays are much more penetrating and can be detected outside the body by means of a Geiger Müller counter and this enables the isotope to be traced in the body and its concentration in the thyroid or other tissues recorded In addition ^{131}I has a half life of eight days which means that it decays to half its original strength in that period and there is therefore plenty of time to convey it to the patient

The advantages of ^{131}I therapy in hyperthyroidism are obvious The patient is spared a surgical operation and anaesthetic There is no risk of injury to the recurrent laryngeal nerves or to the parathyroids There is no immediate reaction to the treatment, which exerts its effect gradually over several weeks so that the maximum benefit is seen in two to three months

The disadvantages of this form of therapy are twofold First it is difficult to calculate the required dose because this depends primarily on the number of grams of thyroid tissue present in the patient s neck and even the most experienced clinician finds this difficult to assess Over dosage leads to hypothyroidism and the patient has to take thyroid or thyroxin daily under dosage means that the treatment will have to be repeated We have found a dose of 150 microcuries per estimated gram of thyroid tissue satisfactory The second disadvantage is the risk of malignant change in the thyroid at some future date as a result of the intense radiation it receives In the early days of roentgen therapy many patients were overtreated and subsequently developed cancerous changes in the skin, sometimes after the lapse of twenty years Whether ^{131}I therapy for hyperthyroidism produces thyroid cancer will not be known for at least another ten years In the experimental animal thyroid cancer has been produced by ^{131}I given alone or with prolonged thiouracil feeding but it would be unwise to draw any conclusions therefrom at present

by giving Neo Mercazole 10 mgm three times a day for six weeks and then adding Lugol s iodine during the last two weeks before operation

With such preparation the patient arrives at operation completely relieved of hyperthyroidism and no special form of pre operative medication or post operative management is necessary

Indications for Thiouracil Therapy in Hyperthyroidism

Thiouracil, which in this country is usually given in the form of methyl thiouracil prevents the thyroid gland from manufacturing thyroxin It will thus render a patient non toxic, but in so doing the thyroid usually becomes larger and more vascular because the anterior pituitary is no longer inhibited by the presence of circulating thyroxin The patient is given 0 1 to 0 2 gm three times a day and the symptoms are markedly relieved in one or two weeks, the improvement continuing until in six to twelve weeks the patient is euthyroid It is possible then to reduce the dosage to 0 05 to 0 1 gm per day by mouth and continue it indefinitely Poate of Sydney has given thyroid sicca with the thiouracil in long term therapy in order to minimize the increase in size and vascularity of the gland and on stopping the therapy after one to two years has obtained many remissions Others have remarked on the high incidence of recurrence after the drug has been stopped Although there are not enough comparable figures to give a definite assessment of this type of treatment probably not more than 40 per cent remain cured after one year

The disadvantages of prolonged thiouracil therapy are that some patients develop toxic reactions to the drug the commonest being a skin rash and the most serious agranulocytosis The latter has accounted for most of the deaths from thiouracil Its incidence has varied widely in different clinics but need not be more than 2 per cent

Propyl thiouracil has been widely used in the United States but this may have been due to its superiority over methyl thiouracil during its experimental trials in rats In man propyl is not as effective in equal doses as methyl thiouracil and with the increased doses necessary toxic reactions are about as common The combination of iodine with the thiouracil molecule in the form of di iodo thiouracil (Itrumil) has found favour with some but in our hands appears to be of less value than iodine and thiouracil used separately An extremely powerful anti thyroid drug mercap toimidazole (Neo Mercazole) is now past its trial stage it is likely that other more potent and less toxic substances of this kind will be discovered in the future

selected because of the suspicion of malignancy It is therefore misleading to say that 10 per cent of these non toxic nodular goitres were malignant What is true is that 10 per cent of the nodular goitres excised were malignant

TABLE XI

Author	Per cent Single Nodules excised found to be Malignant	Per cent Multiple Nodular Goitres excised found to be Malignant
Warren Cole *et al* (1945) Chicago	24 0	17 1
Warren Cole *et al* (1949)	24 4	17 1
Crile, G , Jun (1949) Cleveland	24 5	10 9
Cope O *et al* (1949) Boston	19 0	10 0

It is therefore important to know what are the indications that should lead to the suspicion of malignancy in a nodular goitre for it is clearly impossible and undesirable to recommend thyroidectomy for all enlarged thyroid glands In order to do this it is necessary to understand the difficult problem of the pathology of malignancy That so many different classifications exist is good evidence that none is wholly satisfactory

Pathology

It is convenient to consider thyroid cancer under two headings, papillary carcinoma and non papillary carcinoma Papillary cancer accounts for between one third and one half of all malignant thyroids It may occur at any age and it shows a tendency to appear in the younger age group being invariably the variety seen in childhood It is often a slowly growing tumour and there are records of patients who have harboured such a cancer for thirty years with little increase in its size It has a predilection for spreading by lymphatics, and this accounts for the previous concept that lateral aberrant thyroid tissue might be found in the neck Such tissue results from the spread of a highly differentiated papillary tumour into a cervical lymph node, and a careful search in the lobe of the thyroid on the same side of the neck will reveal the primary Occasionally the primary tumour is minute—the so called occult carcinoma of thyroid

Non papillary cancer can be subdivided into groups according to its histological appearance

(*a*) Adenocarcinoma with colloid formation reproducing fairly faithfully the parent gland

It must also be stressed that radioiodine therapy can only be carried out in certain hospitals because it requires the co operation of a physician, surgeon and physicist who are conversant with the techniques involved In addition much expensive and elaborate equipment for measurement and careful safeguards to prevent irradiation hazards to the nursing staff are necessary

Briefly ^{131}I therapy should at present be reserved for patients whose expectation of life is less than twenty years, for those who have had one or more thyroidectomies especially if a recurrent laryngeal nerve has been damaged and for those who have such severe cardiovascular disease that they are unsuitable for a surgical operation Finally, it is suitable for those with severe exophthalmos especially if associated with ophthalmoplegia since a gradual reduction in the hyperthyroidism is less likely to lead to worsening of the eye changes It should not be contemplated in young patients or those with toxic nodular goitre

CANCER OF THE THYROID

Thyroid cancer is not common in England and Wales The Registrar General s returns for 1943–47 attributed 1 481 deaths to it, or approximately 300 deaths per annum Pathologists have for long found the diagnosis of malignancy in the thyroid a difficult task as the existence of such self contradictory terms as benign metastasizing goitre testifies

Cancer in Nodular Goitre

In 1945 two articles were published from clinics in Chicago (Warren Cole) and New York (Hinton and Lord) recording an incidence of 7 to 17 per cent cancer in non toxic nodular goitre A five year follow up published later stated that many of the Chicago patients were already dead of malignant disease so that there could be little doubt of the correctness of the diagnoses There followed throughout the world a quickening of interest in the incidence of malignancy in thyroid nodules This incidence was claimed to be minimal by such workers as Van der Laan who based their figures on the post mortem records of two large hospitals Since many with thyroid cancer go home to die their estimate was almost certainly too low On the other hand the surprisingly high incidence reported by the Chicago workers might in part be due to their being in an area of endemic goitre In such areas many of the population have nodular goitres and thyroidectomy is only performed on the most carefully selected patients—who are often

mastoid muscles and the jugular vein Such a course of action will be preferable to having to return to a scarred neck at a later date, to remove further nodes A history of extremely slow growth probably justifies the less radical excision

Non papillary carcinoma may present in a variety of ways At one extreme the diagnosis of malignancy is not even suspected and a non toxic, or very rarely a toxic nodular goitre is excised, the pathologist subsequently reporting an early cancerous change At the other extreme a patient, who has had a goitre for many years, seeks medical advice because of rapid enlargement of the neck with pressure symptoms Compression of the trachea may necessitate tracheotomy and the patient may die within a few weeks

The treatment of a patient with a malignant goitre should be guided by certain clearly defined principles As soon as the diagnosis of malignancy has been confirmed at operation an attempt should be made to perform total thyroidectomy If successful this serves two purposes the removal of the primary growth, and the removal of all normal functioning thyroid tissue The latter is of value in that in some patients the anterior pituitary may then stimulate metastases to take on the production of thyroxin thus making them accessible to treatment by radioactive iodine Total thyroidectomy in a patient whose thyroid is enlarged and distorted by carcinoma can be a formidable undertaking Moreover, it is essential to preserve at least one recurrent laryngeal nerve and one or more of the parathyroids For these reasons radical excision may have to be confined to one side of the neck Pretracheal muscles and one internal jugular vein may be sacrificed together with all the involved tissue that is removable The tumour may have to be sliced off the trachea When necessary, the operation is completed by performing a tracheotomy Attempts have been made recently to resect part of the trachea and replace its walls by tantalum gauze and fascia Two weeks later a block dissection of the lymphatic drainage is made on the side of the neck primarily involved if it has not been possible to do this at the original operation It may be necessary to repeat this on the opposite side if the tumour is extensive and involving the isthmus or contralateral lobe

When a patient who has had a slowly progressing tumour for years finally presents for treatment because of difficulty in breathing, it is advisable to resect as much of the tumour as possible before starting radiotherapy

There is a rare form of anaplastic thyroid neoplasm which produces a rapidly enlarging tumour with a smooth surface Histologically the cells resemble a sarcoma or completely undifferentiated

(*b*) Adenocarcinoma without colloid formation and less differentiated than the foregoing

(*c*) Carcinoma simplex, a solid tumour with varying degrees of differentiation

In practice every degree of differentiation is seen from a tumour which is only distinguishable from normal thyroid tissue by its powers of spread outside the capsule of the gland Such a tumour may produce a distant metastasis in bone from which biopsy appearances are those of normal thyroid tissue At the other end of the scale is the rapidly growing solid tumour indistinguishable histologically from a sarcoma One further variety the Hurthle cell tumour is of particular interest to the pathologist Hurthle cells which are large pink granular cells are often seen in the thyroid especially in Hashimoto s disease A Hurthle cell carcinoma is typically made up of these large cells surrounding small follicles

Diagnosis

When a solitary nodule is palpated in the thyroid of a young person the diagnosis of papillary carcinoma should be entertained until proved otherwise by a surgical excision which should include a generous amount of paranodular tissue The younger the patient the more likely is the nodule to be malignant In multi nodular goitres the risk of a malignant change is low unless the gland has recently undergone rapid enlargement the nodules feel hard there is dysphagia or the patient has the impression that all is not well in her neck Hoarseness due to involvement of a recurrent laryngeal nerve is pathognomonic of malignancy

Treatment of Thyroid Cancer

Surgery The most important treatment for every patient with carcinoma of the thyroid is a surgical operation but the form which that operation should take must be decided by the variety and extent of the tumour

Papillary carcinoma may be diagnosed on the operating table when a lymph node excised from the neck is found to contain metastatic thyroid tissue If the disease is confined to one side of the neck it suffices to perform a hemi thyroidectomy and remove all apparently involved lymph nodes Since these patients are often young girls more mutilating operations are not usually justified If the tumour has crossed the midline a generous part of the contra lateral thyroid lobe should be excised When many lymph nodes are involved it will be advisable to proceed at once to a formal block dissection of the neck removing the infra hyoid and sterno

tous, or is only hypothyroid for a few months, and then returns to a euthyroid condition This is because the metastases are now manufacturing enough thyroxin for the patient's requirements Such a patient is usually well suited for radioiodine therapy

The practice of giving patients with carcinoma of the thyroid a tracer dose of radioiodine to see if the tumour or its metastases take up significant amounts is of little if any value It gives no indication of how the metastases will behave after the normal thyroid tissue has been removed

In order to stimulate still further the metastases to take on function methyl thiouracil in large doses can be given (0 6 gm to

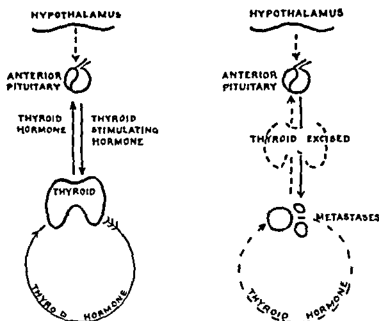


Fig 13. See text

2 0 gm per diem) for two to three months The drug is then stopped and after two days an increase in iodine uptake is likely The thiouracil appears to produce changes in the metastases comparable to those in the normal thyroid i e disappearance of colloid increase of acinar cell height and increase in vascularity and overall size of tissue The use of T S H by injection is of little use for it cannot be obtained in a pure state at the present time

When the iodine uptake in the patient s metastases has been developed to the maximum the therapeutic dose of ^{131}I is given by mouth after a brief fast The concentration of the radioactive material in the secondary deposits can be gauged by placing a Geiger counter over them and the total uptake is determined by

carcinoma These tumours are radio sensitive and respond favourably to a course of radiotherapy They usually recur fairly rapidly in other parts of the body, but the patient is spared death due to obstruction of the trachea

X-Ray Therapy X ray therapy is most valuable when used for the anaplastic type of thyroid carcinoma These quickly growing tumours appear to melt away if given intensive irradiation of the order of 4 000 roentgen to the neck and upper mediastinum When they recur, it is usually in the form of metastases in the lung and liver

Radiotherapy may be used as an adjunct to surgery where there has been incomplete removal of an infiltrating tumour Conversely surgery may be a useful adjunct to radiotherapy The presenting part of the tumour is excised and a tracheotomy performed as a prelude to radiotherapy in patients who are brought to hospital at a late stage of the disease

Occasionally a solitary lung deposit causes troublesome hæmoptysis and then palliative irradiation of 2 000 roentgen given to the secondary over ten days is worth while

Radioiodine Radioiodine is only of value in the treatment of metastatic deposits and can only be used if the tumour cells take up enough of the isotope to irradiate themselves adequately Since less than 50 per cent of thyroid carcinomas take up appreciable amounts of iodine the applications of this form of therapy are limited

A thyroid metastasis even when well differentiated never takes up iodine as well as the normal thyroid gland For this reason it is first necessary to remove all normal thyroid tissue so that it no longer competes for the radioactive iodine The most satisfactory method of ablating the thyroid gland is to perform the operation of total thyroidectomy When the patient is too frail for this or there is much scarring in the neck from previous operations it may be preferable to destroy the normal thyroid with a large therapeutic dose of radioiodine

After total thyroidectomy there is a reduction in circulating thyroxin This reduction leads to increased activity of the anterior pituitary especially the basophil cells which are responsible for manufacturing thyroid stimulating hormone T S H Reference to the accompanying diagram will make this clear The increased output of T S H by the pituitary induces cells in the thyroid metastases to manufacture thyroxin for which purpose iodine is taken up from the blood stream Occasionally after total thyroidectomy for thyroid cancer the patient does not become myxœdema

(normal level 3 2 mgm per 100 c c of blood plus or minus 0 5 mgm) accompanied by an elevation of the serum calcium (normal level 10 0 mgm per 100 c c of blood plus or minus 1 0 mgm) with the excretion of calcium in the urine This is accompanied by decalcification of the skeleton The condition is commoner in females than males and the pathological finding is usually an adenoma of one parathyroid gland In about 10 per cent there are two adenomata In some 10 per cent there is hypertrophy or hyperplasia of all four parathyroids with no adenoma formation Carcinoma of these glands is rare

The clinical findings fall naturally into three groups (1) bone disease (2) urinary tract disease (3) symptoms due to hypercalcæmia

(1) Bone disease may not occur in hyperparathyroidism if the patient drinks plenty of milk When it does occur it is called von Recklinghausen s osteitis fibrosa cystica, though there is considerable doubt as to whether von Recklinghausen did in fact describe this condition The changes seen are decalcification cyst formation and tumour like masses of osteoclasts and fibrosis Cysts occur typically in the jaws (an epulis should always raise the suspicion of a parathyroid tumour) metacarpals and metatarsals The vertebræ often collapse causing a decrease in height which may be further accentuated by bowing of the femora Crush fractures of thoracic vertebræ may lead to a pigeon breast deformity Pathological fractures are common and a biopsy finding of osteoclastoma in such circumstances may deceive the surgeon until generalized skeletal changes are discovered at a later date Bone pains are common and backache one of the earliest complaints

(2) In the urinary tract the commonest finding is a calculus Many patients with hyperparathyroidism are discovered in the genito urinary department because they present with recurring renal tract stones In addition there may be polyuria accompanied by polydypsia In the later stages of the disease, nephrocalcinosis i e calcification mainly in the tubules of the kidney leads ultimately to renal failure, It is occasionally visible as calcified streaks in X rays of the kidneys

(3) The raised serum calcium is accompanied by hypotonicity of the skeletal muscles The E C G may show a decreased Q—T interval Calcium may be deposited in many tissues, and in the eye can be recognized as a band keratitis

Operation The first exploration of the neck for a parathyroid tumour offers the best opportunity for finding it and should therefore be planned with care and carried out in an unhurried and

measuring the amount excreted in the urine and subtracting it from the dose given We have so far only been able to treat thyroid metastases in this way in very few patients Life has been prolonged but in none has the disease been completely destroyed

To summarize the most important form of treatment for thyroid cancer is still a radical surgical excision For anaplastic tumours radiotherapy is most useful For well differentiated tumours which have metastasized it is sometimes possible to treat the secondaries with radioiodine

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THE PARATHYROIDS

THE parathyroid glands were discovered by the Swedish anatomist Sandstrom in 1880 and in 1925 Felix Mandl performed the first operation for removal of a parathyroid tumour in a patient with generalized fibrocystic disease of bone In the same year Collip prepared physiologically active parathormone and by the early 1930 s Sir James Walton in this country and Doctors Churchill and Cope in America had successfully operated on a number of patients with hyperparathyroidism This then is a disease which in surgical history was only discovered yesterday and is still commonly over looked to day

The normal parathyroid glands secrete a hormone which according to Albright regulates the phosphate excreted by the kidney In hyperparathyroidism there is lowering of the serum phosphorus

CHAPTER XXV

THE ADRENALS

SELWYN TAYLOR

The surgical treatment of adrenal disorders represents one of the more dramatic recent advances in surgery Kendall s work on the identification of adrenal cortical hormones, leading in recent years to a plentiful supply of compound E or cortisone has made such operations relatively safe A brief outline of the physiology of the adrenals will serve as an introduction to the subject

Each adrenal gland is composed of an outer yellow cortex and an inner reddish brown medulla The cortex is essential to life and produces hormones controlling carbohydrate protein and electrolyte metabolism The medulla is not essential to life it produces adrenaline and nor adrenaline Destruction of the adrenals leads to Addison s disease and death but the patient can be kept alive by the administration of added salt in the diet and desoxycorti costerone acetate, DOCA, which is a synthetic cortical salt hormone In addition cortisone may be given and leads to a greater sense of well being and corrects any tendency to hypoglycæmia The various pathological states which may require surgical treatment are summarized diagrammatically in Fig 136

Disorders of the Adrenal Cortex

(1) Cushing's Syndrome This term originally referred to a clinical picture (described below) associated with a basophil tumour of the pituitary Since many of these patients have no pituitary tumour and since they all have either a tumour or hypertrophy of the adrenal cortex it is convenient to describe them all as Cushing s Syndrome and to reserve the term Cushing's Disease for those who also have a pituitary tumour It is not known whether the pituitary tumour can over stimulate the adrenals and as regards treatment, it is reasonable to disregard the pituitary aspect of Cushing s Disease

Cushing s Syndrome is much commoner in women than men Clinically there is

(1) Great obesity especially of the abdominal wall which shows

meticulous fashion The four glands normally lie on the postero lateral surface of the thyroid in relation to the termination of the two superior and two inferior thyroid arteries The middle thyroid veins will need ligation before each lateral lobe of the thyroid is rolled gently towards the midline Absolute hæmostasis and avoidance of staining of the tissues with blood are essential The *parathyroid glands have a distinctive tan colour, and once one has* been identified it is much easier to find the others (just as in birds nesting) If an adenoma is found it is removed *in toto* If all four glands are hypertrophied three are excised and about 200 mgm of the fourth left with an intact blood supply Parathyroids may be found in the anterior or posterior mediastinum or in the substance of the thymus it is rarely necessary to split the sternum to complete the search

Post operative care is mainly directed at keeping the serum calcium above the level at which tetany appears If there has been generalized decalcification of the skeleton this may be difficult for after removing the parathyroid tumour the bones are ' hungry *for calcium The only way to slow up this passage of calcium into* the bones is by lowering the phosphate intake and this means avoiding milk and cheese in the diet Calcium should be given in large doses by mouth and if tetany occurs an immediate intra venous injection of 100 ml of a 10 per cent solution of calcium gluconate or lactate will provide relief Calciferol (vitamin D) can also be given to maintain the level of serum calcium, but may delay the recalcification of the skeleton Patients in the immediate post operative period may show strange mental aberrations, becoming testy and unreasonable in their demands on the nursing staff

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FIG 137 Straight X ray after air insufflation showing normal adrenals



FIG 138 Straight X ray after air insufflation The patient presented with Cushing's syndrome and the X ray shows a tumour of the right adrenal which was subsequently removed

striae, and of the face which becomes moon like A cervico thoracic fat pad presents a "buffalo" appearance

(2) A thin skin, a ruddy complexion acne, and an increased susceptibility to bruising

(3) Muscular weakness

(4) Diabetes which is mild but resistant to insulin

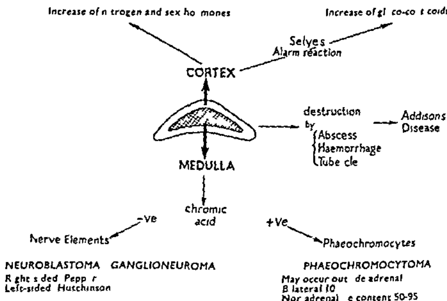


FIG 136 Adrenal dysfunction Diagram showing the more common adrenal disorders

[Figs 136–139 by courtesy the Editor *Postgraduate Medical Journal*

(5) Osteoporosis especially of the spine

(6) Amenorrhœa or impotence

(7) Hirsutism with normal or only slightly increased excretion of urinary 17 ketosteroids The gluco corticoids are usually relatively increased in the urine

(8) Hypertension degenerative arterial disease, headache and mild polycythæmia

(9) Mental depression and personality changes

The diagnosis can sometimes be confirmed by air insufflation and straight X rays or tomography of the adrenals Blackwood's peri renal pneumography is excellent for this purpose With the patient

the other Thus a bilateral exposure is usually necessary There are three surgical approaches to the adrenals (a) With the patient lying prone the twelfth rib can be excised subperiosteally and a good view obtained If the patient be fit enough both sides can be explored at the one operation (b) The adrenals may be approached across the peritoneal cavity This is a difficult operation in an obese female since it is impossible to palpate the adrenals satisfactorily and they always have to be fully displayed (c) The third approach is by the usual loin incision used for nephrectomy when traction on the kidney will give adequate exposure of the adrenal The drawback is that the patient must be turned before the second side can be operated upon if both are to be explored at one time

The results of surgery in Cushing's Syndrome are most encouraging Now that cortisone is available, the mortality rate has fallen from about 25 per cent to a low level For example sixteen consecutive patients have recently been operated on at the Mayo Clinic for subtotal adrenalectomy without a death the operation being done in two stages Patients so treated return in large measure to normal, but a small number require treatment for adrenal insufficiency where the excision has been too radical or show a poor response when the excision has been too conservative Failure in the past to obtain a good response appears always to have been the result of not removing enough adrenal tissue

(2) **Adrenogenital Syndrome** This is *made up of two factors* virilism and a disordered nitrogen metabolism leading to great muscle mass The cause is either a tumour or bilateral hypertrophy of the adrenal cortex The clinical picture varies according as to whether the excess adrenal secretion occurs in fœtal life before puberty or in the adult

The effect of the adrenogenital syndrome on a fœtus is to produce a pseudohermaphrodite Typically a female child is born with a large clitoris and varying degrees of pseudomasculinity Such a baby may be thought to be a male with undescended testes

In the child before puberty the adrenogenital syndrome produces sexual precocity in boys and masculinity in girls There is greatly increased muscular development hairiness deep voice adult sex organs in the male and an early fusion of the epiphyses This is the so called infant Hercules

When an adult woman develops this syndrome she *develops a* masculine type of build and appearance prominent muscles partial baldness and amenorrhœa Very rarely a male adult may undergo a feminizing change

in the lateral position a lumbar puncture needle is inserted just in front of the coccyx and directed into the presacral hollow 400 ml of air are injected on each side and X rays are taken after the patient has walked about for twenty minutes (Figs 137–139)

The treatment of Cushing s Syndrome is by the excision of the adrenal tumour when one is present, or subtotal adrenalectomy when there is bilateral hypertrophy of the adrenals The patient is given 200 mgm of cortisone by intramuscular injection daily for



FIG 139 Tomograph after air insufflation The patient presented with Cushing s syndrome and the X ray shows bilateral hyper trophy of the adrenals which were later subjected to sub total adrenalectomy

two days before operation and lesser amounts by mouth for a week post operatively This is to avoid the nausea anorexia and prostra tion which otherwise accompany a sudden deprivation of adrenal secretions Adrenocorticotrophic hormone (A C T H) may be given subsequently to stimulate the patient s remaining adrenal tissue

It is often impossible to determine the side of the tumour and if hypertrophy is present it is necessary to expose both adrenals before proceeding to the excision of one and about seven eighths of

injection of a 2 per cent solution of benzodioxane (piperidyl methyl benzodioxane) 10 mgm per square metre of body surface may be used. It is adrenolytic and lowers the blood pressure if the elevation is due to circulating adrenaline. Unfortunately it acts as a pressor in essential hypertension so it is not without risk. *Dibenamine* (N N dibenzyl beta chloroethylamine hydrochloride) given slowly intravenously at the rate of 7 mgm per kilo body weight is another adrenolytic test, the action is much more prolonged up to twenty four hours. No pharmacological test for phaeochromocytoma has proved universally successful. At the present time Engel and von Euler's method of estimating the urinary concentrations of adrenaline and nor adrenaline appears to be the most reliable aid in the diagnosis of phaeochromocytoma. Unfortunately the method is elaborate and only available in specially equipped laboratories.

The treatment of phaeochromocytoma is the surgical removal of the tumour and this was first successfully accomplished by C. H. Mayo in 1927. The best approach is an anterior one through the abdomen since about 10 per cent of these tumours are multiple and they have also been described lying some way distant from the adrenals especially in relation to the abdominal aorta.

The greatest gentleness is essential during the operation as handling the tumour leads to severe hypertension. The tumour should not be manipulated until the vascular pedicle has been secured. The commonest cause of death and this operation still carries a high mortality is due to the severe shock like state that may follow the removal of the tumour. This shock may not be reversed even when large amounts of adrenaline are given intravenously. The discovery that many of these tumours contain a high percentage of nor adrenaline has resulted in a solution of this substance being given by slow intravenous infusion throughout the operation. As soon as the blood pressure falls the nor adrenaline is run in more quickly. For at least twenty four hours after the operation the infusion is continued very slowly being speeded up as required thus tiding the patient over hypotensive episodes which might otherwise be fatal.

Total Adrenalectomy in Malignant Disease

Total excision of the adrenal glands with maintenance of the individual on daily cortisone can cause some regression of neoplasms, especially cancer of the prostate and cancer of the breast. Cox observed a dramatic if temporary clinical improvement after subtotal adrenalectomy in a patient with multiple secondaries from prostatic cancer. Huggins has reported the results of total adrena

Diagnosis of the adrenogenital syndrome is confirmed by a much increased excretion of 17 ketosteroids in the urine Air studies of the adrenals may show a tumour or hypertrophy The treatment is similar to that described for Cushing s Syndrome but if a tumour is not found subtotal resection may not be attended by such good results as in Cushing s Syndrome

Disorders of the Adrenal Medulla

The adrenal medulla develops from sympathetic nervous elements If it is stained with chromic acid the part which goes brown is the chromaffin tissue and it is this which secretes adrenaline and nor adrenaline and from which a phæochromocytoma may arise The part not staining with chromic acid is sympathetic nerve cell tissue and may give rise to the neuroblastoma of childhood

Phæochromocytomata appear typically in young adults of either sex and about 10 per cent of the tumours are bilateral They produce a secretion which may be made up from 50 to 95 per cent of nor adrenaline and the remainder adrenaline The difference between these two hormones is important since adrenaline acts as an overall vasodilator and only causes a raised blood pressure through increased cardiac output Nor adrenaline on the other hand, acts as an overall vasoconstrictor with little direct effect on the heart

The main manifestation of a phæochromocytoma is the production of paroxysmal attacks of hypertension when the systolic pressure may rise to 300 mm Hg and the diastolic to 200 mm The patient goes pale and sweats has a violent pulsating headache and may collapse Liver glycogen is mobilized during an attack the blood sugar raised and also the basal metabolic rate (B M R) The attacks usually become more frequent and more severe with the passage of time and may be mistaken for hyperthyroidism a thyroidectomy *being performed in error*

The diagnosis is confirmed when pressure in one loin or over a palpable tumour initiates an attack Often the patient knows on which side the lesion is situated Intravenous pyelograms may show displacement of a kidney and air studies may demonstrate the tumour Roth and Kvale proposed a test in which 0 025 to 0 05 mgm of histamine is injected intravenously and serial blood pressure readings made In the presence of a phæochromocytoma the pressure reaches a high peak in two minutes

Difficulty arises in differentiating between those patients who have a persistently raised blood pressure due to a phæochromocytoma and those with essential hypertension The intravenous

PART VIII—PRINCIPLES OF TREATMENT OF MALIGNANT DISEASE

SIR STANFORD CADE

SINCE the last edition of Recent Advances progress has been made in the treatment of malignant disease in many ways The surgical treatment of cancer in certain sites has made advances both in technique and in a better understanding of the limitations of excisional treatment The combination of surgery and radio therapy has become more rational and at the same time more limited New techniques in surgery and in radiotherapy as well as advances in the knowledge of the pathology and the natural history of cancer have widened the therapeutic field The study of hormones in their relationship to two sites of cancer—the breast and the prostate—have resulted in new methods of treatment which prolong life diminish discomfort control pain and affect in many ways the progress of the disease Chemotherapy by cytotoxic poisons has made available new compounds which have a controlling effect on certain tumours

lectomy in eighteen patients with extensive metastases They required 50 mgm of cortisone and 3 gm of salt daily by mouth for maintenance When orthostatic hypotension occurred DOCA 2–4 mg was given in addition

In patients with prostatic cancer there was an increase in weight rise in hæmoglobin concentration and fall in serum acid phosphatase The most striking observation however was the immediate and persistent relief of bone pain Of the six patients with advanced breast cancer only three showed improvement Four patients with advanced cancer of other organs showed progression of their disease after adrenalectomy

Clearly this form of surgery must be regarded at present as investigative rather than therapeutic

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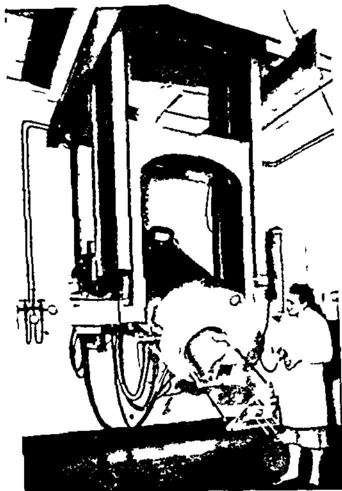


FIG. 140 Supervoltage X ray therapy at two million electron volts Van de Graaff generator

disease These technical advances permit the application of radio therapy to widely disseminated lesions, to deep seated and in accessible tumours which previously were beyond the range of radiotherapy

Advances in Radiotherapy

Surgeons treating malignant disease should be familiar with the possibilities and the limitations of radiotherapy The following brief review has been written with the object of presenting to the surgeon the newer methods of radiotherapy their indications and their value No technical details are included and it is now pre sumed that the biological effects of radiation on normal and malignant tissues and the general principles underlying technique are

CHAPTER XXVI

RADIOTHERAPY

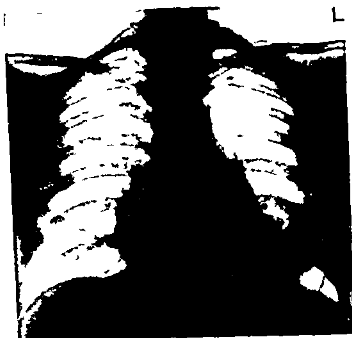
Advances in Available Apparatus

In the comparatively brief period since the discovery of X rays and of radium their application in the treatment of cancer has depended partly on technical achievements in the construction of apparatus but mainly on the advances in physics and in the development of a new speciality that of the hospital physicist and the acceptance by the clinician of the partnership with applied science in the treatment of cancer

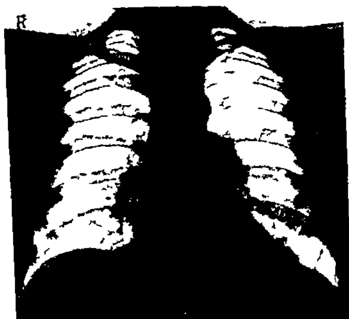
Supervoltage Radiotherapy and Isotopes

These modern and powerful methods of applying ionising energy to the tissues have received a great impetus from the second world war and the rapid strides in the progress of atomic energy the establishment of atomic piles and the numerous radioactive isotopes which have become available

In addition to the low voltage X rays at 60 to 150 K V and the medium voltage at 200 to 400 K V there are now in clinical use X ray generators of 2 million electron volts (Fig 140) Such apparatus is in daily clinical use and has many advantages The most obvious is the possibility of delivering at a depth a greater dose than on the skin this can be achieved with far less skin and mucosal reaction and enables the radiotherapist to increase the tumour dose well beyond what was possible with conventional types of apparatus The experimental clinical use of linear accelerators of 4 million and 8 million electron volts further widens the field of radiotherapy Similarly the use of artificial radioactive sources as opposed to natural radioactive material such as radium has technically enabled sources of radiation of 1,500–2,000 curies to be applied clinically Of these radioactive Cobalt 60 is used for distance radiotherapy in a manner similar to teleradium but with a radiation source increased from 10 gm of radium to an equivalent 200 times as powerful Cobalt is also used in smaller units equivalent to 40 to 50 curies of radium and also in needles similar to radium needles Other radioactive isotopes phosphorus gold sodium iodine are also used by injection or by mouth to control certain types of malignant



(a)



(b)

FIG 141 Pulmonary metastasis from seminoma of testis (a) Before radiotherapy (b) Five weeks later showing complete dis appearance of metastases

sufficiently well known to need no detailed description Radio therapy can be used as the sole method of treatment or in combination with surgical excision and further as a presumed prophylactic measure, to prevent or lessen the incidence of post operative recurrences A knowledge of cancer as a disease, an appreciation of the influence of the stage of the disease on the choice of the method of treatment and a clear conception of the limitations of both radiotherapy and surgery is essential and should prevent the use of either method to the detriment of the patient Certain common sites of cancer have been selected to review the present state of radiotherapy, its indications and limitations and to illustrate the advances made in treatment

Tumours of the Testis

This site is chosen as an example of the prophylactic use of radiation This attempt at preventing metastases in their commonest site namely the para aortic lymphnodes has been successful and has altered fundamentally the outlook of the majority of patients The evolution of the treatment of testicular neoplasms in modern times was in stages At first simple orchidectomy was done as this method did not prevent the subsequent development of lymphnode metastases and gave only about 7 per cent of five year survival the so called radical operation was advocated first by Chevassu in France (1906) and by Hinman in the United States (1933) The results were improved yet the improvement gave only about 17 per cent of five year survival malignant tumours of the testis still had a very grave prognosis It was natural therefore to try radiotherapy and this led to a return to simple orchidectomy associated with radiotherapy to the abdominal lymphnodes Since then results have shown a consistent improvement Dean (1937) reported a series of 170 patients with a 29 per cent of five year survival Ahlbom (1947) a series of 119 cases with 50 per cent of 5 year survival There is in fact no other site of a primary malignant growth where the advent of radiotherapy and its prophylactic use has altered the prognosis so fundamentally The study of the pathology of testicular tumours has advanced simultaneously To day it is well known and understood that of the two common pathological varieties the seminoma is of better prognosis and the teratoma of much graver outlook The difference in incidence and age distribution of these two types is well known It is important to point out that seminoma is one of the most radio sensitive tumours whereas teratoma is radio resistant Yet it must be emphasized that whatever the histological type post operative

urinary bladder Partial cystectomy is of limited indication, when the tumour is small, papilliferous in type and has involved the muscles of the bladder Endoscopic diathermy destruction of papillary growths should be considered as a palliative measure, it is only applicable to the warty growth and not to the ulcerative and infiltrating type Conventional X rays at 200-250 KV has been extensively tried it is of slight palliative value and may control hæmorrhage but it is quite useless from the curative point of view It must be admitted that the so called "deep X rays" have failed signally to control cancer of the bladder Radium on the other hand has given much better results Insertion of radium needles or radon seeds with or without additional diathermy destruction of the exuberant superficial parts of the tumours has given control of the disease in a good percentage of cases In those centres where this method is practised and radium is introduced by wide supra pubic cystostomy and accurately placed in position worth while results are achieved and frequently total disappearance of the lesion is recorded for many years With this technique a tumour dose of 8 000 r can be given without undue risk of radionecrosis

Although the results of radium needling have as yet not been surpassed by other methods of radiotherapy the general dissatisfaction with conventional X rays has given great impetus to the trial of other methods Cavitary radiation was first tried by placing a radioactive source radium in the centre of a Foley s catheter when inflated the sphere kept the radium in the centre at a given distance of the bladder wall The advent of radioactive isotopes permitted a similar technique using radioactive sodium and when radioactive cobalt became available this method was further developed With such methods a much higher tissue dose up to 8 000 r -9 000 r can be given and hence greater control of disease is obtained However the occurrence of delayed but severe post radiation effects was often recorded The cystitis and early radium burn of the older methods was found to occur somewhat later with the newer techniques The euphemistic term systolic bladder could not hide the fact that severe radiation necrosis and fibrosis often resulted from intracavitary radiation with isotopes or single cobalt sources either in the form of radioactive cobalt wire or in the form of curved needles which permitted a more accurate placing of the needles into the bladder wall Radiotherapy therefore has returned to the surgical approach using more modern radioactive sources

The most promising recent advance is in the use of supervoltage X rays at 2 million volts Experience with the Van De Graaff

radiotherapy is indicated and that the prognosis is improved in both types, although much more so in seminoma

Management of Patients with Testicular Tumours

Once the diagnosis is established, simple orchidectomy should be performed This should be done even in patients with metastases in the regional lymphnodes and elsewhere, such as in the lungs or in the skeleton Simple orchidectomy not only gets rid of the primary tumour but establishes an accurate histological diagnosis Radiotherapy to the abdomen should be given in all cases It is in fact of great value in patients who have no clinical evidence of abdominal lymphnodes The lymphatic drainage of the testis is direct to the para aortic glands, but also to the internal iliac glands There is a very free lymphatic communication between all these lymphnodes and those at and above the renal vessels further there is also a free communication between the lymphnodes on both sides A rational treatment therefore should include the pelvic and abdominal areas It is therefore at present a generally accepted method to treat the entire lymphatic field Treatment can be given by conventional X rays at 250 KV or by supervoltage X rays at 2 M E V or by teleradium or telecobalt As the seminomas are highly radiosensitive total tumour doses of about 4 000 r are sufficient for seminoma in teratoma the dose should be increased to 5 000 r–6 000 r

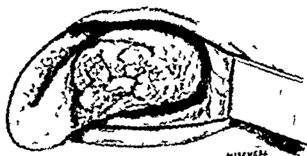
The results fully justify this combination of simple orchidectomy and radiotherapy Of the patients treated prophylactically in the absence of clinically demonstrable metastases 65 per cent survive five years in the case of seminoma and 55 per cent in the case of teratoma (Cade 1952) But even when metastases were present when the patient was first seen about 15 per cent of five year survival was obtained (Prosser 1951) In seminoma pulmonary metastases are equally radiosensitive and may disappear completely after treatment (Fig 141) pulmonary metastasis from teratoma are very radio resistant

Carcinoma of the Urinary Bladder

This site is chosen as an instance where modern methods of radio therapy have been tried and developed in an attempt to control the disease Advances can be recorded both in surgical treatment and in radiotherapeutic methods Surgically total cystectomy with removal of the prostate in men has established for itself a definite and useful place in treatment transplantation of ureters into the bowel is commonly practised and permits total ablation of the

disease Cases suitable for surgical treatment form about 7 per cent of the total seen As it is either the failure to respond to radiation or an extra lingual spread of the disease which dictates excision, the operative procedures had to be altered and so advances in surgical treatment achieved

Surgical Treatment In the case of the tongue itself if ablation



(a)



(b)

Fig 142 Carcinoma of tongue (a) before radium treatment (b) after radium treatment Ten years survival without recurrence

is decided on it should be carried out intra orally, with the diathermy needle In the case of lesions involving the floor of the mouth or the mandible access is by reflexion of a flap consisting of the lip and part of the cheek The skin incision should extend through the whole thickness of the tissues down to the chin and posteriorly to the edge of the masseter An adequate portion of the mandible should be excised and in most cases half the mandible is removed disarticulating at the temporo mandibular joint Closure

generator is now available in several centres in Great Britain and the results are of considerable promise Used either as the sole method of therapy or in combination with cystodiathermy a very high tumour dose can be given 6 000 r –8 000 r , never achieved by the conventional X ray apparatus at 250 KV Such treatment is spread over six to eight weeks and is given in daily treatments aiming at 1,000 r per week The skin reaction is negligible the bladder reactions are moderate and cause only moderate dysuria and frequency Periodic cystoscopic examinations show that the effect on the tumour does not occur for some time varying from six to twelve weeks the tumour then gradually shrinks and often dis appears This method does not exclude the subsequent systolic bladder ' but this is of far lesser degree of severity and occurs less frequently The use of curved cobalt needles interstitially and of supervoltage X rays as an external form of irradiation are in fact real advances

Cancer of the Tongue and Mouth

Radiotherapy for malignant lesions in the tongue and mouth has been practised for over thirty years It is now an established method of treatment and the majority of primary lesions in this site are submitted to radiotherapy as the first or initial treatment (Fig 142) Advances in technique and in selection of method of treatment have been made since the last edition of this book with the general progress of radiotherapeutic methods The principles are now well established and can be summarized as follows —

The treatment of choice in most cases as far as the primary growth is concerned is radiotherapy in the case of the regional lymphnodes the treatment of choice is surgical excision Thus this site provides an instance of a combined radio surgical treatment with well defined indications for each method The stage of the disease nevertheless is the determining factor thus the policy out lined above applies to early cases and the reverse is the treatment of choice in advanced cases where ablation of the tongue or of the lesion in the mouth and radiological treatment of the cervical lymphnodes is the choice

A review of the accepted methods of treatment is that radiation is the first choice in the treatment of the primary growth with certain well defined exceptions Surgery is preferable to irradiation (1) where the disease has extended beyond the tongue and invaded the mandible (2) where the whole tongue down to the circum vallate papillæ is involved by a hard nodular infiltrating growth (3) where previous treatment by radiation has failed to arrest the

6,000 r–8,000 r with little damage to the rest of the mouth or the skin and with hardly any general effect on the patient and only a small risk of local radionecrosis

The method of gammatherapy depends upon the actual site of the lesion For lesions in the buccal mucosa and anterior part of the tongue interstitial therapy is the method of choice (Figs 143 and 144)



FIG 144 Combined needling and mould in the treatment of a carcinoma of the buccal mucosa and lip Four needles are shown inserted deep to the lesion A box carrying a quantity of needles is applied outside the lip and cheek The neoplasm is thus irradiated from two sources

Radium needles radon seeds or the more modern cobalt 60 needles which can be straight or curved and offer greater flexibility of technique can be used

Needling of the tongue can be done either in a single plane implant for lesions of moderate size or by a two plane or volume implant in tumours of greater bulk

In the case of lesions of the pharyngeal part of the tongue involving the valeculla oral aspect of the epiglottis or glosso palatine folds distance radiation by teleradium or telecobalt is the method of

of the buccal cavity is achieved by careful stitching of the mucosa of the flap to the floor of the mouth the skin is closed separately and the space between the newly formed mouth floor and the skin should be drained externally

Radiotherapy There is no doubt that gamma radiation has



FIG 143 Radium needles in tongue 10 000 r delivered in seven days The extensive carcinoma involving the whole anterior part of the tongue disappeared and the tongue healed

given much better results than X ray therapy at the conventional 200–250 KV The explanation may be found in the difference of wavelength and hence difference in the biological effect or in the increased total dose which is greater with gamma rays than X rays there is no doubt clinically that the achievement of gamma radiation surpasses that of X rays in the case of epithelial cancer of the mouth and tongue Gamma radiation can be given up to a total dose of

Treatment of the Cervical Lymphnodes

It is now accepted in most important centres that in the absence of enlarged cervical lymphnodes, an expectant policy is justifiable Prophylactic radiotherapy for the neck is no longer practised, neither is prophylactic block dissection advised if the patient can be kept under routine supervision

The indications for block dissection, which is the method of choice for enlarged cervical lymphnodes are clear cut and can be summarized as follows —

(1) The primary lesion in the mouth should be healed

(2) The lymphnodes should be clinically enlarged, palpable, but mobile

(3) The general condition of the patient should not preclude a major surgical intervention

A block dissection and not the removal of the enlarged lymph nodes should be done It must include the deep cervical fascia from the mandible to the clavicle from the midline anteriorly to the anterior edge of the trapezius posteriorly The internal jugular vein the sterno mastoid omo hyoid and posterior belly of the digastric must be removed if a complete clearance of the lymphnodes is to be achieved in the anterior, posterior, submandibular and supraclavicular areas It is now well known that bilateral block dissection with excision of both internal jugular veins is safe but it is still customary to allow an interval of about seven days or more between the removal of the first and second internal jugular veins The spinal accessory nerve is cut high up in the neck and also lower down near the posterior edge of the trapezius

Indications for Radiotherapy for Cervical Lymphnodes

Control of the disease can only be accomplished if the lymphnodes are mobile and can be removed together with the deep cervical fascia Adherence of the nodes to the main vascular sheath or fixation of the enlarged lymphnodes to the muscles render the case unsuitable for surgery although it is still operable technically In such cases radiotherapy should be decided on in preference to surgery Radiotherapy can be given by teleradium, supervoltage X rays or needles In most cases external radiation is preferable to needling

Cancer of the Larynx

This is essentially an endolaryngeal lesion, within the framework of the laryngeal cartilage It is a neoplasm of the vocal cord and of the ventricular band Its natural extensions are forwards to the

choice (Fig 145) Ten gram radium units 50 curie telecobalt units or more recently very powerful apparatus containing 1 500–2,000 curies of cobalt 60 are used External radiotherapy can also be used with confidence with X rays at 2 million volt or 4 million linear accelerators These powerful and recently developed methods deliver high intensity radiation which can be focused on the lesion

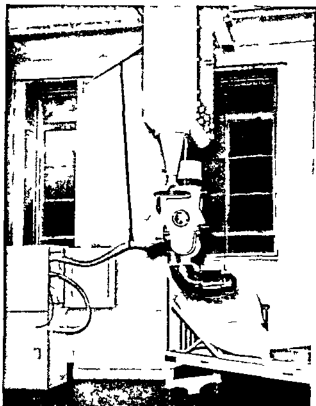


FIG 145 10 gram teleradium unit with mechanical transfer of radium from the safe into the applicator Similar apparatus can be used for 60 curie radio active cobalt

and deliver a total dose of 6 000 r to 8 000 r or more so reaching tissue doses achieved by interstitial methods without any severe effects on the skin It is now well known that in the majority of patients such treatment given with skill and accuracy leads to complete regression of cancer of the mouth and healing which is long lasting The advantage of radiotherapeutic methods over surgical local ablation is the lack of mutilation preservation of function and a greater chance of permanent control of the disease

clude subsequent laryngectomy. In the external method of treatment both X rays and teleradium can be used. Except for its tediousness the method offers many advantages. Those who have both radiotherapeutic facilities available prefer teleradium. M. Lederman (1952) points out that there are technical, physical and clinical reasons for this. The ease and simplicity of teleradium is preferable to the conventional X rays. The differences in the wavelength of radiation, in the percentage of depth dose and in the shape of the radiation beams are the advantages of teleradium. There is ample clinical evidence that with less post radiation effects on the skin and mucous membrane, there is better response as regards regression of the tumour and greater freedom from recurrence. There is evidence that supervoltage X rays at 2 million volt upwards, and telecobalt units are as effective as teleradium and superior in every way to conventional X rays at 250 KV. The great change in the choice of treatment during the past few years is a reversal of policy. Whereas previously early and favourable cases were treated surgically and advanced cases by radiotherapy, to day the position is reversed, and early endolaryngeal cancer is confidently submitted to radiation. Surgery is selected for the advanced cases and for radiation failures.

Indications for Surgery. In patients with old standing pachydermia of the cords, where the carcinoma is a metaplasia of the pre existing precancerous condition. In radium failures, that is when the disease is not controlled by adequate doses given with a good technique. In advanced and extensive lesions. In subglottic extension.

Indications for Radiotherapy. In early and localized lesions. In advanced cases as a pre operative measure.

To ensure that radiation in advanced cases does not jeopardize the chances of laryngectomy, certain rules as to the management of radiation must be adhered to. A predetermined total dose not exceeding 5 000 r is aimed at; if no regression is obtained, radiation is discontinued. If partial regression is obtained, a time limit must be set, for instance four to six weeks, to assess the result. Persistence of the lesion indicates the need for a further biopsy and if this is positive laryngectomy should not be delayed. It is very important to recognize radiation failures and distinguish them from delayed reaction, radionecrosis or perichondritis.

Bone Sarcoma

Sarcoma of bone can be classified into four main types: (1) osteogenic sarcoma, (2) Ewing's tumour, (3) Multiple myeloma

anterior commissure and to the base of the epiglottis downwards to the subglottic space posteriorly to the arytenoids In the decision as to the choice of the method of treatment and in assessing the results of various methods, a classification according to the exact site and extent of the tumour is of importance The earliest stage of the disease which may aptly be called carcinoma *in situ* or stage 0 is in fact only detected by biopsy and occurs mostly in cases with pre existing disease of the cords such as hyperkeratosis It is in fact a precancerous state similar to the leukoplakia familiar in the mucous membrane of the mouth and elsewhere such as the urinary bladder and the vagina

The commonly accepted classification is as follows —

Stage I	Lesion of anterior two thirds of one vocal cord
Stage II	Involvement of both vocal cords and anterior commissure
Stage III	Extra cordal extension with fixation of vocal cord
Stage IV	Involvement of other parts of the larynx

The disease can spread proximally to the ventricle of Morgagni to the false cord and to the laryngeal aspect of the epiglottis More significant is the extension distally to the subglottic space It is important to diagnose such downward spread very early as lesions with subglottic extension or primary subglottic carcinoma are difficult to control by radiation and many of such cases eventually require laryngectomy The accurate diagnosis of the site and extent of the disease and of the histological grading is of great importance in the choice of treatment and in the management of the patient

Choice of Method of Treatment Two problems arise in the decision as to the choice of treatment (1) Surgery or radiotherapy ? (2) If radiotherapy what method ? V E Negus (1947) in an analysis of the relative merits of the available methods points out that the discomforts during and after treatment must be considered Laryngofissure is the least distressing surgical method convalescence is rapid the voice is hoarse and apart from this there is no disability Laryngectomy interferes with swallowing for a short time tracheotomy is permanent oesophageal speech can be acquired or a vibrating rod used The operation is a major one with permanent subsequent disability Of the radiological methods interstitial radium requires an operative intervention if successful the voice is almost normal The treatment is of short duration and tracheotomy is not needed Radium perichondritis is an occasional sequela If unsuccessful fenestration of the larynx does not pre

clude subsequent laryngectomy In the external method of treatment, both X rays and teleradium can be used Except for its tediousness the method offers many advantages Those who have both radiotherapeutic facilities available prefer teleradium M Lederman (1952) points out that there are technical, physical and clinical reasons for this The ease and simplicity of teleradium is preferable to the conventional X rays The differences in the wavelength of radiation in the percentage of depth dose and in the shape of the radiation beams are the advantages of teleradium There is ample clinical evidence that with less post radiation effects on the skin and mucous membrane, there is better response as regards regression of the tumour and greater freedom from recurrence There is evidence that supervoltage X rays at 2 million volt upwards, and telecobalt units are as effective as teleradium and superior in every way to conventional X rays at 250 KV The great change in the choice of treatment during the past few years is a reversal of policy Whereas previously early and favourable cases were treated surgically and advanced cases by radiotherapy to day the position is reversed, and early endolaryngeal cancer is confidently submitted to radiation Surgery is selected for the advanced cases and for radiation failures

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Bone Sarcoma

Sarcoma of bone can be classified into four main types (1) osteogenic sarcoma (2) Ewing s tumour (3) Multiple myeloma

TABLE XII — *Main Characteristics of Primary Tumours of Bone*

Type	Incidence of all bone tumours	Age (years)	Sex	Type of bone affected	Order of frequency	Site of origin in bone	Metastasis	Radiographic appearances	Histology
1 Osteogenic sarcoma	50%	10-20	$\frac{M}{F}=\frac{4.5}{3}$	Long bones (any bone)	1 Femur 2 Tibia 3 Humerus 4 Pelvis 5 *Fibula* 6 Scapula	*Ends (Metaphysis)*	Lungs Other bones	Rarefaction Sclerosis New bone formation Codman's triangle Sun ray spicules	Spindle cells Pleomorphic cells Bone Cartilage Osteoid tissue
2 Ewing's tumour	12.5%	5-15	$\frac{M}{F}=\frac{2}{1}$	Long bones (short bones)	1 *Tibia* 2 Fibula 3 Humerus 4 Femur 5 Jaw 6 Small bones	Centre *(Diaphysis)*	Skull Lymph glands Lungs Other *viscera* Subcutaneous	Sclerosis *of cortex and medulla* onion peel New bone Patchy rarefaction	Round *or* polyhedral cells Very scanty Inter cellular stroma
Multiple myeloma	3%	40-60	$\frac{M}{F}=\frac{2}{1}$	Flat bones	1 Ribs 2 Vertebrae 3 Sternum 4 Skull 5 Pelvis 6 Clavicle	Centre (Medulla)	Spleen Liver	Bone destruction No compensatory new bone formation	Round *or* oval cells Plasma cells (giant cells)
lastoma enign)	20%	16-30	Equal incidence	Long bones Jaws Pelvis Scapula		Ends	None	Expansion *Thinning of* cortex Trabeculation *No new bone* formation	Multinucleated giant cells (15-50 nuclei) Round cells Spindle cells (stroma) Vascular spaces

(4) the malignant variety of osteoclastoma The development of bone tumours is controlled by the same physiological processes as those which occur in the response of bone to injury and inflammation Thus the formation of callus absorption of bone sclerosis all occur in varying degrees in bone sarcoma and indeed a history of trauma is common both in osteogenic sarcoma and in *Ewing s tumours*, and not infrequent in other varieties Bone sarcoma may originate from any tissue possessing bone forming properties, from bone itself or cartilage from bone marrow or the endothelium of the blood vessels Each type of tumour has a somewhat different natural history and differs in many respects in age of onset skeletal distribution incidence radiographic appearance and metastatic spread (Table XII) The histological appearance is characteristic of each type Thus osteogenic sarcoma is essentially a spindle cell tumour with a marked pleomorphism of the stroma which may contain bone cartilage osteoid tissue, fibrous tissue in any proportion The cartilage containing osteogenic sarcoma may be primary or develop from a pre existing and apparently benign chondroma the so called secondary chondrosarcoma The cell unit of Ewing tumour is a round cell in multiple myeloma the characteristic cell is the plasma cell with an excentric nucleus A variety of round and polygonal cell—the reticulum sarcoma of bone is now recognised The multi nucleated giant cell is the characteristic cell of osteoclastoma both benign and malignant

Diagnosis This is based on the clinical history physical signs and radiological appearance But all these can be misleading and abnormal or unusual features in other pathological processes callus formation ossifying hæmatoma or low grade inflammation may cause considerable difficulty in diagnosis Similarly, some osteo lytic varieties e g the telangiectatic osteogenic sarcoma are at times difficult to distinguish from a metastatic bone tumour from a hypernephroma or other clinically silent primary growth and it is now well known that Ewing s tumour may be confused with skeletal metastasis from a neuroblastoma Neither can the solitary type of multiple myeloma " the plasma cell tumour or plasmocytoma be readily distinguished from an osteolytic metastasis Biopsy there fore is of great importance and there is in fact no evidence that biopsy in bone tumour is dangerous and likely to disseminate the disease It is however essential to provide the pathologist with a representative piece of tumour and this cannot as a rule be obtained except by open operation Aspiration biopsy is very useful in multiple myeloma and a sternal or illiac crest marrow puncture is now a routine procedure

Effect of Radiation on Bone Sarcoma Sarcoma of bone shows varied degrees of radiosensitivity Ewing s tumour is the most sensitive osteogenic sarcoma the least so Osteolytic lesions show a more obvious response to radiation than the sclerosing variety

There is clinical radiological and histological evidence that bone sarcoma is influenced by adequate radiation The following changes are seen (1) Progressive diminution in size of the tumour (2) recalcification of osteolytic lesions (3) resorption of abnormal bone (4) healing of pathological fractures , (5) restoration of the contour of the bone Comparison of biopsy material taken before and after radiation shows arrest of mitosis, abnormal mitosis increased fibrosis Like in other tumours so in bone sarcoma the response to treatment is variable and in some patients no changes are observed

Treatment Amputation remains the main treatment but as the results of amputation do not seem to prevent metastasis in the majority of patients other methods of treatment likely to improve the prognosis can be tried Radiation is used as the sole method if amputation is refused or if the tumour is irremovable Radiation should be used in conjunction with surgery in all cases in view of the poor results of surgery and in the knowledge that radiation alters the course of disease Radiation should precede surgery and there is no evidence that delay in amputation adversely affects the patient s expectation of life Treatment by super voltage X rays or teleradium should be given slowly spread over six to eight weeks often longer There is evidence that high tissue doses are more effective than lower doses Thus 8 000 r to 9 000 r give better results than 4 000 r such doses are now possible with super voltage X rays whereas with conventional X rays it resulted in radio necrosis The present day views as regards *treatment can* be summarized as follows —

Osteogenic Sarcoma (Figs 146 147 148) A radio resistant tumour *which* requires large tissue doses Surgery *remains* the main treatment pre operative radiation as a routine is advisable and there is no harm in the delay in amputation

Ewing s Tumour *(Fig 150) A highly radio sensitive neoplasm* it responds rapidly to radiation which should always be the first method of treatment Regression is often complete although not *often permanent*

Multiple Myeloma (Fig 149) Radiation is used for the relief of pain Being a multi focal disease surgery has no place in *the treatment* Radiation relieves pain The use of cytotoxic poisons, such as derivatives of Nitrogen Mustard combined with œstrogens



FIG 146 Osteogenic sarcoma of femur Telangiectatic variety with marked osteolysis Female aged eleven years



FIG 147 Osteogenic sarcoma of tibia Radiograph of a thin slice of the amputation specimen showing the tumour within the cancellous part of the bone and invasion of the soft tissue by bursting through the periosteum



Fig 148 Osteogenic sarcoma of humerus Sun ray spicules Codman's triangle invasion of soft tissue Male aged nineteen years Multiple pulmonary metastasis



Fig 149 Multiple myelomatosis Plasma cell tumour The vertebræ ribs and pelvic bones were also affected



Fig 150 Ewing's sarcoma of tibia Radiograph of specimen after amputation



Fig 151 Osteoclastoma of tibia Giant cell tumour

has been shown to control the disease and prolong life, sometimes by several years

Osteoclastoma (Fig 151) This is most commonly a benign lesion although the malignant variant is well recognized although rare In the benign variety both surgery and radiation give satisfactory results The choice of treatment depends upon the following factors site size and type of tumour and the age of the patient The typical tumour producing bone expansion trabeculation and thinning of the cortex responds better to radiation than the solitary cyst like lesion Surgery is indicated in preference to radiation

1 In young patients when the tumour is in close proximity to the epiphysis and irradiation may be followed by arrest of growth at the growing end of the bone
2 In tumours of moderate extent when the destruction of bone is limited and the cavity left by curetting small
3 When the tumour has extended into the neighbouring joint

Radiotherapy is indicated

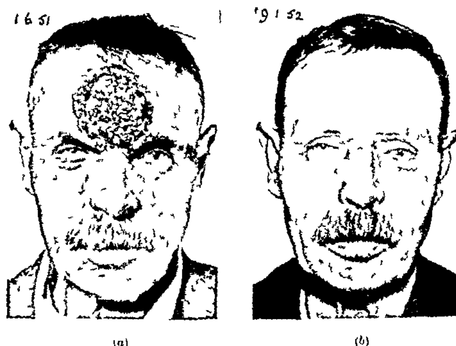
1 In healthy adults
2 When the tumour is difficult of access, such as in the spine or the pelvis
3 In tumours showing radiologically the "soap bubble" appearance

The total dose required to produce recalcification of the tumour is small in the region of 2 000 r in children and 3 000 r in adults The immediate response to treatment often shows increase in swelling and pain and further decalcification this is however a temporary effect lasting a few weeks and is followed by healing It is generally agreed that the combination of treatment by curetting with or without grafting, with radiotherapy is not advisable If the tumour is completely removed radiation does not hasten repair To be effective radiation should be given without preliminary scraping In malignant osteoclastoma the treatment is similar to that of osteogenic sarcoma

Malignant Disease of the Skin

Malignant lesions of the skin comprises three different types of lesions (1) Rodent ulcer or basal cell carcinoma (2) Epithelioma or squamous cell carcinoma and (3) Malignant melanoma or naevus cell carcinoma Lesions can occur on the skin or on the muco cutaneous junctions such as the lip conjunctiva, anus and vulva Certain sites such as the penis require special consideration and other such as cancer of the scrotum is a notifiable disease in certain occupations

Rodent Ulcer In this lesion radiation has proved of such value that in most clinics it has become the routine treatment (Fig 152) In early and previously untreated cases 90 per cent of freedom of disease is obtained and 70 per cent in cases where structures other than the skin are involved Although rodent ulcers are sensitive to radiation and often regress completely with as little as 1,500 r, to ensure permanency of results 5 000 r should be given Radiation can be given by low voltage X rays, radium or a surface application of radio active phosphorus (beta radiation) Surface radiation in



(a) (b)

Fig 152 Rodent ulcer of the forehead of many years duration previously untreated (a) Before treatment by teleradium (b) Seven months later showing complete healing of the lesion and a healthy scar

superficial small lesions or needling in excavating or thick lesions is indicated The achievement of low voltage X rays by the contact method is limited by the depth of the lesions and as the rays do not penetrate beyond a few millimetres sterilisation is assured in superficial lesions only The importance of the method of radiation lies not so much in the achievement of immediate primary healing which presents no great difficulty as in the permanency of the results obtained It is noteworthy that the very high percentage of cures of rodent ulcers by radiation is obtained in previously untreated specially previously non irradiated lesions The results of made

quate radiation, specially by X rays but also by repeated surface radium or other forms of treatment caustics snow limited local excision etc when assessed in a true light show that such treatments rob the patient of his best chance of cure Inadequate irradiation is a greater evil than inadequate surgery and small doses of X rays repeatedly given over long periods should be condemned

Although radiotherapy is the method of choice in untreated cases in those where the bone or cartilage is involved in recurrent cases in certain sites such as the ears surgery and diathermy alone or in conjunction with radium have a useful place in the treatment



(a)



(b)

Fig 153 Epithelioma of penis (a) Before treatment (b) Three months later showing lesion completely healed

Epithelioma Surgery and radiation each have an important place in the treatment of this type of skin cancer Previous radiation either therapeutic or occupational exposure with subsequent dermatitis are a contra indication to radiotherapy For lesions on the trunk or back or on the thigh excision has the advantage of speed and simplicity in large lesions excision and skin graft is indicated In lesions on the hand feet *perineum and vulva surgery* is safer and by excision the risk of a radiation burn is eliminated In lesions on the face in all sites where avoidance of scarring is important radiation is preferable and gives 70 per cent. of five years freedom of disease

Epithelioma of Penis The choice of the method of treatment

depends primarily on the extent of the disease early cases are best treated by radiation (Fig 153) late cases by surgery (Fig 154) Complete healing of the lesion without mutilation or functional disability can be obtained by radiation in early cases The contraindications to radiotherapy are (1) Involvement of the urethra by



Fig 154 Extensive carcinoma of penis Not suitable for radium therapy and should be treated by surgery *Patient under the care of* Mr C Jennings Marshall M S F R C S at Charing Cross Hospital

an infiltrating growth (2) Advanced lesions when the body of the penis is involved (3) Spread of the tumour to the corpora cavernosa or to the corpus spongiosum (4) In diabetics because they are apt to develop necrosis X rays surface radium or needles can be used

Malignant Melanoma These tumours are radioresistant and

their treatment by radiation is difficult and disappointing, there is however, a definite place for radiation in the treatment of this highly malignant tumour (Ellis, 1939) Surgery remains the method of choice and extensive and radical local removal should be attempted wherever possible Radiation preferably by radium is indicated in the following cases, when adequate excision is not possible in multiple tumours in local recurrences after extensive resection for inoperable lymphnodes the seat of metastases as a pre or post operative measure

CHAPTER XXVII

HORMONAL CONTROL OF CANCER

IN 1896, Beatson, at the Glasgow Cancer Hospital took out both ovaries in a patient with advanced cancer of the breast This was the dawn of remote or hormonal control of cancer Since then attempts have been made to achieve the same result by X radiation castration The experimental work of Charles Huggins in Chicago on the physiology of the prostate his observations on the excretion of acid phosphatase in prostatic cancer and E C Dodds synthesis of stilbœstrol have been the most important steps in the development of a completely new method of controlling cancer in two sites the breast and the prostate Advances in biochemistry the laboratory production of œstrogens other than stilbœstrol and of a variety of androgens have made it possible to castrate chemically as well as surgically and radiologically

So far no other neoplasms other than those of the breast and prostate are known to be capable of being influenced by male and female sex hormones The fundamental importance of these observations is the fact that cancer in these two sites can be influenced by a change in the hosts hormonal environment Studies of the ketosteroid metabolism indicate that steroid hormones are only produced in the presence of the gonads and of the adrenals The removal of these organs so affects the normal course of mammary and prostatic cancer that control of the disease is obtained even in advanced and generalized widespread metastatic disease involving most of the skeleton and in visceral and cutaneous metastases The removal of the gonads and of the adrenals contrasts vividly with the modern trend of radicalism in the excisional attack on growths

The surgical procedures—bilateral oophorectomy subcapsular bilateral orchidectomy and bilateral adrenalectomy are to day in the light of experience limited both in time and in numbers of patients observed still very much in the experimental stage But the dramatic change in the general and local condition of patients in the terminal stages of cancer in these two sites the reprieve from apparently certain *death within a brief period renders this newest of* all methods worthy of extensive trial

The administration of œstrogens in prostatic cancer and of

androgens and œstrogens in mammary cancer are now well established and universally practised methods of treatment. Their usefulness and their limitations are well known.

Bilateral Oophorectomy. This operation by itself has a temporary effect on the cancer of the breast. Œstrogenic activity of the ovary is abolished, whereas by radiologically induced menopause it is only partially influenced. Castration, however, is followed by the formation of œstrogen by the adrenals and the benefit of the operation is therefore temporary. At present it is used as an adjuvant to androgen therapy.

Bilateral Subcapsular Orchidectomy. This simple surgical measure is effective in the control of cancer of the prostate. It obviates the need of œstrogen administration and so eliminates the unpleasant side effects such as pigmentation, enlargement of the breasts and nausea. It prolongs the period of control as it may by itself be effective for two years when further improvement can be obtained by œstrogens.

Bilateral Adrenalectomy. This operation has been rendered possible by the availability of cortisone. Most patients are stabilized on 50 mg. of cortisone daily. The efficacy of adrenalectomy can be judged by the rapid disappearance of pain from skeletal metastasis and the improvement of the general state of the patient which often returns to a near normal state.

Not all cancers of the breast and prostate respond to hormonal treatment; it is at present not known why this should be so. Huggins believes that the adeno-carcinoma is the most likely to respond to bilateral adrenalectomy, but the author's experience shows that the scirrhus type, carcinoma simplex and medullary carcinoma of the breast respond as well.

CHAPTER XXVIII

PELVIC VISCERECTOMY

Operability in Pelvic Cancer

ADVANCES in surgical technique have resulted in a readjustment of the limits of operability Technical operability should be distinguished from suitability for surgery In malignant tumours of the pelvic viscera specially uterine cancer, the disease may be widespread locally and yet not give rise to metastases in the liver or other viscera More rarely in cancer of the rectum or pelvic colon and even less frequently in cancer of the bladder there may be direct extension of the primary growth to the adjoining viscera without visceral metastases Such cases judged by the accepted criteria of operability—that the tumour should be limited to the organ of origin and mobile and that the enlarged lymphnodes should be limited in extent—were considered beyond surgical help In many such patients the lesion often cancer of the uterine cervix had already been submitted to radiotherapy These patients are in a pitiful state often with recto vaginal or vesico vaginal fistulæ Urine fæces pus mucous blood and pieces of tumour escape through the vagina rectum and perineal fistulæ To these patients the offer of any surgical procedure however wide and mutilating remains the only hope and is nearly always accepted

Indications for Pelvic Viscerectomy

1 In cancer of the uterus where the disease is beyond the widest Wertheim s hysterectomy This includes cases where there is involvement of adjoining viscera—the rectum or bladder obstruction in one or both ureters by the disease in the parametria In post radiation failures these can be primary failures where no response to radiotherapy is achieved or delayed failures when after a variable period of quiescence the malignant growth recurs and spreads It also includes patients with severe post radiation effects in fact radiation burns usually associated with active cancer

2 In cancer of the pelvi rectal junction or rectum specially in young patients when the tumour involves the prostate and bladder in men or the vagina and uterus in women

3 In cancer of the bladder with extension of the disease to the

rectum and prostate in men or extension to the uterus and vagina in women

4 In pararectal local recurrences following Wertheim's hysterectomy

5 In local recurrences following misguided attempts at conservative resection of the rectum

6 In primary carcinoma of the vagina vulva, or extensive recurrences involving the vagina and urethra



FIG 155 Photograph of abdominal wall following complete pelvic viscerectomy It indicates the colostomy in the left iliac fossa and the opening of the new urinary bladder at the upper end of the laparotomy scar at the site of the umbilicus which has been excised

Whatever the condition calling for pelvic viscerectomy there is still the question of operability to be considered When the disease has extended beyond the pelvic fascia and is adherent to the pelvic wall viscerectomy is no longer possible as the tumour will not be cleared sufficiently widely to warrant the extensive procedure Stricture of the ureters hydroureter and moderate bilateral hydronephrosis are not contra indications if the renal function is still adequate Extension of metastases to the abdominal lymphnodes proximal to the aortic bifurcation like visceral metastases precludes the operation Before deciding on pelvic viscerectomy it is impor

tant in all cases to carry out intravenous pyelography and an X ray examination of the bony pelvis the spine and chest to exclude skeletal and visceral metastases A preliminary examination under anæsthesia including sigmoidoscopy and cystoscopy is advisable *Age by itself is no contra indication and the operation has been* successfully performed in patients of seventy five years of age

Wet Colostomy

The original operation devised and first practised by Alexander Brunschwig left the patient with a wet colostomy The author s personal experience has led him to abandon this and to transplant the ureters into an isolated portion of the descending colon and so provide the patient with a urinary fistula separate from the colostomy (Fig 155) This procedure not only makes life more comfortable, but eliminates the recurrent attacks of ascending pyelitis occurring not infrequently in patients with wet colostomies

Variations in Extent of the Operation

Each patient must be considered in detail and the site and extent of the disease will indicate if partial or complete pelvic viscerectomy is to be done Similarly primary disease of the vulva or vagina or extension to the anus and perineum will decide if the excision is to include the vulva anus and perineum An anterior viscerectomy *includes the bladder uterus urethra and vagina* In such cases the ureters are transplanted into the descending or sigmoid colon and a colostomy is avoided Posterior viscerectomy includes the rectum, vagina and uterus a simple colostomy only is necessary and micturition is not interfered with Total viscerectomy includes all *the pelvic viscera and necessitates a colostomy and a urinary* fistula

As the partial procedures are modifications of the total viscerectomy the latter only need be described

Anæsthesia Operations of this magnitude are done with greater ease under hypotensive anæsthesia Hæmorrhage is *negligible* shock is guarded against and the immediate post operative period smooth

Position of Patient The best position for the complete operation, including the excision of the vulva and perineum is that devised at St Mark s Hospital for the synchronous combined abdomino perineal excision of the rectum In this combined Trendelenburg Lithotomy position both the abdominal and perineal vulval parts of the operation are done without changing the patient s position This also enables two surgeons to operate

simultaneously and not only reduces the time of the operation, but renders it an easier and simpler procedure If the abdominal part only is needed, Trendelenburg's position is sufficient

Abdominal Operation A midline incision is made extending from the pubis to the umbilicus If the bladder is to be removed, the umbilicus is excised, otherwise the incision skirts the umbilicus to give adequate approach The liver is palpated for metastases The local extent of the disease is assessed by inspection and palpation, and the extent and site of lymphnode involvement is ascertained The peritoneum over the aortic bifurcation is incised On the right side this incision curves outwards along the common and external iliac arteries This exposes the right ovarian vessels which are clamped, cut across and ligated, the right ureter is exposed and followed down The internal iliac artery and vein are ligated and cut across The right round ligament is cut across at its lateral end The lymphnodes along the external and internal iliac vessels are dissected downwards and medially Carefully preserving the external iliac vessels the obturator lymphnodes are dissected The obturator nerve is preserved and retracted laterally

On the left side, the sigmoid is mobilized by incising the peritoneum on its lateral border The mesosigmoid is separated from the posterior abdominal wall the left ureter is exposed, the mesentery is divided and the left ovarian vessels clamped, and cut across The internal iliac artery and vein are clamped and ligated and the obturator fossa cleared of lymphnodes The mesentery of the sigmoid colon is divided and the vessels clamped and ligated, the pelvi rectal junction and rectum are separated from the hollow of the sacrum by blunt dissection Attention is then turned to the bladder The peritoneum on the anterior abdominal wall is incised and the bladder and perivesical fat separated from the pubis till the urethra is well exposed and separated In the male, the prostate is separated from the retropubic space and the urethra mobilized and both vasa divided

Both ureters are cut across at a level well clear of the disease Two intestinal clamps are placed across the sigmoid and the bowel divided The pelvic contents are now free from all peripheral attachment and held in position by the urethra and the vagina If the perineal stage is deemed unnecessary, the urethra is cut across the proximal part of the vagina freed and divided the rectum is divided just proximal to the anal canal There is no need to suture the cut end of the vagina which is subsequently used for drainage or to suture the anal canal

An artificial bladder which is in fact a small pouch into which



Fig 156 Specimen of pelvic viscera removed in toto by the combined abdominal and perineo vulval operation for a carcinoma of the vagina involving the cervix the uterus the bladder the rectum All of the viscera together with the urethra the vagina the anal canal the vulva and the perineum were removed



Fig 157 Pelvic viscera removed for a carcinoma of the sigmoid colon which has involved the urinary bladder the uterus and the vagina The specimen shows these viscera The urethra the distal half of the vagina and the anal canal the perineum and vulva were not removed

the ureters are implanted is now fashioned A distal segment of the descending colon or sigmoid about 2½ to 3 inches in length is separated from the main bowel by division between clamps, part of the mesentery is divided but this should not interfere with the viability of this small portion of the colon The distal part is carefully closed with two layers of sutures Both ureters are then implanted into the isolated loop the proximal end is brought up to the upper end of the laparotomy incision and sutured to the skin at the level of the previously excised umbilicus The pelvis is denuded of peritoneum is packed with Vaseline gauze, which is brought out through the vagina

The distal end of the descending colon is brought out through a small separate incision in the left iliac fossa to form a colostomy The abdomen is closed without drainage

The Vaseline pack *is left in position twenty four hours, when it is* removed through the vaginal orifice

Perineal-Vulval Stage If this is decided on, it is preferable that this part of the operation should be done by a second surgeon synchronously with the abdominal part A purse string suture closes the anus An elliptical incision is made around the vulva and perineum and is prolonged posteriorly to the coccyx The levatores ani muscles are exposed and cut across at their lateral attachment to the pelvic wall The ischio rectal fossæ are dissected clear The *incision around the vulva is deepened anteriorly to the pubic arch* and laterally At this stage the two surgeons, working together, complete the separation of the pelvic contents and vulva by cutting across the remaining few fibres holding the urethra to the pubic arch The pelvic contents are then removed as one mass (Figs 156, 157) The skin in the perineal wound is closed completely except for the end of the Vaseline gauze pack introduced into the pelvic cavity *as already described and brought out through the* perineal wound The abdomen is closed without drainage

A modified colostomy belt incorporating a de Rutzen bag to collect the urine is worn

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PART IX—ISOTOPES

CHAPTER XXIX

CLINICAL APPLICATION

SELWYN TAYLOR

The word isotope was introduced by Soddy in 1910 when he postulated the existence of more than one stable form of an element In 1934 Joliot and Curie discovered artificial radioactivity and this led to the production of many radioactive isotopes The last *twenty years has witnessed a most vigorous application* of stable and radioactive isotopes to medical problems and the war years saw an intensification of this work The opening of a chain reacting pile at Harwell has provided this country and many parts of the Commonwealth with a regular and inexpensive supply of radio active isotopes It is said that those who make history never have time to read it but when a new field of investigation expands as rapidly as the isotope one it becomes imperative to follow its advances in order to try and keep some sort of perspective The titles of suitable books providing a simple introduction to the physics of the subject and also some of the good comprehensive reviews of the application of radioactive isotopes to biological problems will be found in the list of references at the end of this chapter

Physics

The atoms of any chemical element consist of mixtures of particles with different masses this explains why so many chemical atomic weights are not whole numbers e g Boron has the atomic weight 10 82 and is made up of atoms with masses of 10 and 11 These represent stable isotopes The only stable isotope which has been much used is deuterium or heavy hydrogen in the form of heavy water and it has been employed in the study of water metabolism both in animals and man

Joliot and Curie s discovery of artificial radioactivity led to the introduction of unstable or radioactive isotopes, these isotopes represent elements in which the balance between the outer shell of electrons and the inner nucleus is unstable and these isotopes decay to stable elements by giving off energy in the form of α β or γ rays

or some combination of these three Alpha (α) rays are helium nuclei, they are relatively stable, have an extremely short range and need not concern us here Beta (β) rays are electrons which carry various charges and thus have different powers of penetration Gamma (γ) rays are a form of electromagnetic waves of varying energy and long range

These three kinds of emanation α, β and γ rays can be detected, even when present in the minutest amounts by means of such apparatus as a Geiger Muller tube or a scintillation counter A Geiger Muller (G M) tube in its simplest form consists of an evacuated glass chamber containing traces of argon and alcohol vapour An insulated wire passes down the centre, and a high potential is maintained between the wire and the walls of the tube If the G M tube is now struck by a β or γ ray, the ionization set up between the central electrode and the wall of the tube causes a brief pulse of current to pass along the electrode These pulses can be counted in an electrical device called a scaler

Since radioactive isotopes break down to more stable atoms by giving off radio active emanations it is convenient to measure isotopes in terms of their half lives The half life of an isotope is the time during which half of the radioactive atoms decay to a stable form Such a half life may last minutes days or millions of years according to the characteristics of the element and it is clearly of great importance to know this where isotopes are to be used in the human body

The unit quantity of all radio active material is the curie and since this represents a high degree of activity ($3 7 \times 10^{10}$ disintegrations per second) it is often convenient to use the term millicurie written mc for the thousandth part of a curie and microcurie, written μc for the millionth part of a curie

Isotopes are usually represented by the symbol of the element preceded or followed by the mass number e g C^{12} and C^{13} or ^{14}C and ^{13}C represent two radioactive isotopes of carbon

Radioactive isotopes have been used in the surgical field mainly in three ways to trace to measure and for therapy The use of radioactive isotopes as tracers offers a unique method of investigating fundamental biological problems The radioactive isotope has the same chemical properties as its stable counterpart and is therefore treated by the tissues in the identical way However, its radio active emanations enable it to be detected even though present in amounts far smaller than are capable of measurement by chemical methods For example, if a few microcuries of radioactive sodium (^{24}Na) are injected intravenously into a patient the radioactive sodium

atoms rapidly spread to all parts of the body where stable sodium atoms are present. It thus becomes possible to "trace" the movement and distribution of sodium ions in the body in health and disease since a certain number of the sodium atoms are now "tagged" and their β rays can be detected by a G. M. counter. A specialized application of radioactive tracers of particular interest to the surgeon is in localization studies. For example, by means of radioactive phosphorus and a Geiger Muller counter mounted in a brain needle it is possible to locate brain tumours. Similarly radioactive iodine taken up by thyroid tissue can be mapped out by means of a counter held over the surface of the body.

Radioactive isotopes can also be used to measure various body fluids and to estimate the rate of metabolic processes in the intact human or animal. If a number of red blood cells are "tagged" with radioactive phosphorus they can be introduced into the patient's blood stream and a sample of blood removed later will allow an accurate estimation of the blood volume to be deduced from the degree to which the tagged red cells have been diluted by normal ones. In a somewhat different manner radioactive sodium can be used to measure the adequacy of the circulation in the pedicled skin tube of the plastic surgeon.

In the field of therapy radioactive iodine has been the most widely used isotope being employed for treating hyperthyroidism and the metastases of some forms of thyroid cancer. Radiophosphorus ^{32}P has been used for treating polycythaemia and menorrhagia. Radioactive sodium and bromine have been introduced in solution into the urinary bladder for treating malignant disease. Radioactive gold also has been employed for intracavity irradiation, a colloidal solution being introduced into the pleural or peritoneal cavity for treating multiple metastatic deposits. Finally, a number of solid metals more especially gold seeds, tantalum wire and cobalt have been made radioactive by placing them in the pile with the result that they offer useful alternatives to radium for insertion into malignant tumours.

Special precautions have to be taken to prevent those handling radioactive isotopes from receiving a harmful amount of radiation. This becomes particularly important where isotopes are used therapeutically as for example in the treatment of thyroid cancer with radioactive iodine. Under these circumstances the dose has to be handled with precautions similar to those applicable to radium and in addition the patient's urine has to be stored in lead shielded containers for a few days until its activity has decayed sufficiently for it to be safely jettisoned down the drain. The use

of isotopes demands a discipline which the surgeon may find at first difficult to acquire and, in addition few will be capable of under standing the physics of the problems involved For this reason it is desirable that the application of isotopes to clinical problems should be in the hands of a group made up of surgeon physician and physicist one of whom preferably is experienced in radiotherapy

In order to indicate the ways in which isotopes may be of value in surgery a number of those in common use is listed below together with a brief description of their characteristics and applications It should be realized however that these isotopes have been used only in certain centres in this country and for five or six years at most so that as yet their limitations have scarcely been defined

Radioactive Iodine

The isotope of iodine in common use is ^{131}I which emits most of its energy in β rays but part in γ rays Its half life is eight days

Tests of Thyroid Function It has been used in many different ways as a test of thyroid function and has the merit of being largely free from the subjective errors of clinical judgement Hyperthyroid patients show a more rapid accumulation of the isotope and retain larger amounts for longer periods than normal Hypothyroid patients show a diminished uptake Most normal people take 40 per cent or less of a tracer dose in the first forty eight hours and hyperthyroid patients amounts of over 60 per cent according to the severity of their disease In practice a tracer dose of 5 to 10 micro curies of radioiodine is given by mouth to the fasting patient or injected intravenously The radioiodine is concentrated in the thyroid and can be measured there by a G M counter placed directly over the neck Simultaneously the concentration in the blood can be estimated by placing a G M counter over the thigh and the ratio of neck thigh if plotted over one or two hours will give a reliable index of thyroid activity If a more accurate result is required serial samples of plasma can be counted and compared with counts over the neck If the uptake over the neck is then divided by the plasma level a clearance rate for iodide is obtained In normal people about 20 ml of plasma are cleared of iodide per minute

Serial measurements over the neck and thigh take up much time and if used for a routine diagnostic test can only be done in limited numbers For this reason indirect measurements of thyroid function made by collecting the urine after a tracer dose have some advantage The radioiodine not taken up by the thyroid is excreted in the urine The patient drinks 10 microcuries and is sent

away from hospital with containers for the collection of urine. If at least three periods are taken over a total time of not less than forty-eight hours, good discrimination is obtained between hyperthyroid and euthyroid individuals.

Localization Studies. If a G-M tube is shielded with lead in such a way that it only records the emanations from a tiny area it becomes possible to map out the position and intensity of iodine uptake over the neck and elsewhere. This can be of value to the surgeon since all the thyroid tissue may be situated at the back of the tongue or along the course of the thyroglossal tract, or an enlarged thyroid may extend deeply into the mediastinum. In addition, when there is a swelling in the neck, it may be helpful to know which areas are taking up iodine normally and which are devoid of function.

The patient is given a tracer dose of 100 microcuries of radio-iodine and thirty-six to forty-eight hours later a perspex grid marked in 1 cm. squares is placed over the neck. A special counter with lead shield and central lead core, so designed that it only records parallel rays, is then held over each square for one to two minutes. The counts, expressed as a percentage of the tracer dose, are then plotted on graph paper and if lines are drawn through areas of equal iodine uptake a chart of function is obtained. These lines, which resemble the isobars of the meteorologist, produce a chart which in a normal patient closely resembles the anatomy of the gland.

A nodule in which no radioiodine is taken up is usually referred to as a "cold" nodule and if solitary and in a young patient from a non-goitrous area might raise the suspicion of malignant disease. A nodule taking up more radioiodine than the surrounding tissue is called a "hot" nodule and if associated with clinical signs of hyperthyroidism indicates that removal of the nodule will relieve the condition without recourse to a subtotal thyroidectomy.

Radioiodine Therapy of Hyperthyroidism. See page 365.

Radioactive Phosphorus

The radioactive isotope of phosphorus in common use is ^{32}P which has the convenient half-life of 14.3 days and emits β rays of high energy. ^{32}P gives off no penetrating γ rays, and therefore can only be detected *in vivo* in the skin or very superficial structures; alternatively the counter must be introduced into the tissues.

One of the most valuable applications of ^{32}P has been in the localization of brain tumours. Actively dividing cells such as are found in neoplasms have a rapid turnover rate of phosphorus reflecting the increased metabolism of nucelo proteins accompanying

nuclear division Radioactive phosphorus is thus found in higher concentration in brain tumours than in the surrounding normal brain tissue with its relatively slow metabolism The method used was evolved by Selverstone and depends for its success on a G M counter made in the form of a brain needle of 2 or 3 mm diameter originally designed by Robinson The patient is given 1 millicurie of ^{32}P about twenty four hours before operation and then the G M needle counter is introduced as a probe into the brain substance after the skull and dura have been opened A scaler in the operating theatre shows the surgeon when the counting rate increases that is when the tumour is approached or entered The counting rate in the tumour is five to fifty times as great as that obtained when the needle lies in normal brain substance Morley and Jefferson in this country have reported results similar to the American workers

In the field of therapy ^{32}P has become the agent of choice for treating polycythemia Actively dividing cells take up more of the isotope than resting ones and thus the more active components of the bone marrow are irradiated Chronic myelogenous leukæmia is a recognized complication of polycythæmia but following ^{32}P therapy a number of acute leukæmias has been recorded It is not yet possible to assess whether the incidence of leukæmia has been increased following this form of therapy

Radioactive Sodium

Radioactive sodium has been employed both diagnostically and therapeutically The isotope ^{24}Na is the one in common use it gives off both β and γ rays and has the rather short half life of 14 8 hours which means that fresh supplies have to be obtained from Harwell at frequent intervals

^{24}Na has been used extensively to study the circulation in peripheral vascular disease The most satisfactory technique appears to be the injection of a small amount about 5 microcuries into a muscle and then the rate at which it is removed can be determined by making serial counts over it with a Geiger counter On the whole the method has not proved useful in the routine investigation of patients with vascular disease It has however been of particular value in the study of the vascularity of pedicled flaps as used in plastic surgical procedures Barron and Veall have been able to demonstrate when the blood supply in such flaps is adequate enough to allow them to be detached and swung to the required site By such methods much information has been gained about the blood supply of pedicled flaps and it has been possible to shorten the intervals between the various stages

Radioactive Gold

Radioactive gold ^{198}Au has the short half life of 2 7 days and emits high energy β rays and a lesser proportion of γ rays It can readily be prepared as a colloidal solution and for this reason it has been used for introduction into the peritoneal and pleural cavities when they are the site of multiple malignant deposits The colloidal particles come into contact with a wide surface area of the disease giving it a brief but intense dose of radiation Such therapy has been called the 'gold bath'

In practice, about 100 mc of ^{198}Au in 100 ml or more of solution are introduced after paracentesis of the malignant effusion There follows a variable period of nausea due to the irradiation and approximately half the patients treated in this way are improved Occasionally this palliative treatment is remarkably successful the effusion not recurring for many months and there being a striking relief from pain and cachexia

A second method of using radioactive colloidal gold which has been mainly pioneered in the United States is its injection directly into superficial tumours especially those on the face or in the breast Multiple injections are made and a more uniform spread of the radioactivity in the tumour is obtained by adding hyaluronidase In successful cases the tumour shrinks and is replaced by fibrous tissue A further elaboration of this technique has been experimented with in Switzerland whereby the ^{198}Au is combined with pectin to form large particles which, when injected intravenously are selectively taken up by the lungs A few patients with inoperable lung tumours have benefited from treatment in this manner

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In the field of therapy, ^{32}P has become the agent of choice for treating polycythemia Actively dividing cells take up more of the isotope than resting ones and thus the more active components of the bone marrow are irradiated Chronic myelogenous leukaemia is a recognized complication of polycythaemia but following ^{32}P therapy a number of acute leukaemias has been recorded It is not yet possible to assess whether the incidence of leukaemia has been increased following this form of therapy

Radioactive Sodium

Radioactive sodium has been employed both diagnostically and therapeutically The isotope ^{24}Na is the one in common use it gives off both β and γ rays and has the rather short half life of 14 8 hours which means that fresh supplies have to be obtained from Harwell at frequent intervals

^{24}Na has been used extensively to study the circulation in peripheral vascular disease The most satisfactory technique appears to be the injection of a small amount about 5 microcuries into a muscle and then the rate at which it is removed can be determined by making serial counts over it with a Geiger counter On the whole the method has not proved useful in the routine investigation of patients with vascular disease It has however been of particular value in the study of the vascularity of pedicled flaps as used in plastic surgical procedures Barron and Veall have been able to demonstrate when the blood supply in such flaps is adequate enough to allow them to be detached and swung to the required site By such methods much information has been gained about the blood supply of pedicled flaps and it has been possible to shorten the intervals between the various stages

PART X—THE NERVOUS SYSTEM

D. W. C. NORTHFIELD

CHAPTER XXX

CEREBRAL SURGERY IN MENTAL ILLNESS

The application of surgery to the treatment of mental illness by Moniz and Lima in 1935 has led to great activities in this field by all concerned. In an endeavour to place this form of treatment on a rational basis and to rid it of its empiricism there have been critical pre- and post-operative studies of the patients, various modifications of the standard leucotomy of Freeman and Watts have been attempted and painstaking anatomical examinations have been made of the brains of patients dying after the operation.

In the last edition of this volume it was pointed out that although leucotomy might not lead to any impairment of reasoning power or decrease of general intelligence there was usually a lowering of ethical values; the patients "are relieved of all sense of personal responsibility and of anxious self-questioning as to the ethical rightness of their conduct" (Golla, 1946). In some cases more conspicuous disturbances arise: aggressiveness, inertia, laziness and total disregard for the ordinary social code. Where leucotomy is carried out for the relief of the symptoms of a severe psychosis the pre-operative personality may be already so depraved that by contrast the result of leucotomy is a relative gain; but when the operation is performed for, say, a severe anxiety tension state, damage to the personality by the operation may be so evident as to render its value questionable in that particular case. Considerable work has been carried out in devising suitable tests and criteria for classifying results. Some tests may be regarded as predominantly assessing intelligence and others memory; some ability to form judgments and to solve problems; the estimation of emotional reactions, of ethical standards and of the reaction to the stresses of the social environment are outside the scope of formal tests and must depend upon the subjective opinion of observers. In order to arrive at a useful body of evidence it is advisable to study all possible approaches to the problem and the result of formal tests must not be given undue prominence. Freeman and Watts (1950)

Radioisotope Techniques 1953 Vol I H M Stationery Office London
Symposium on Radioactive Isotopes 1949 *J Clin Invest* 23, 1247

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Mayer Gross (1947) is correct, that leucotomy if successful provides the patient with a new frame work of personality This emphasizes the need for prolonged and careful post operative rehabilitation and assessment of home conditions to determine whether these and the relatives affection, capabilities and intelligence are adequate for the responsibility

Strom Olsen and Tow (1949) in an important paper have compared and contrasted the late results in two groups of patients 100 chronic severely disordered psychotics, inmates of a mental hospital, all with the worst prognosis—and 25 patients admitted to hospital specifically for the operation on account of severe neurotic depression, obsessive compulsive states and tense hypochondriasis Operation in the first group (c) was undertaken to ameliorate severe behaviour disorder, but in the second group (a) the aim of operation was to secure full social rehabilitation The results of operation have been studied under various categories, the effect upon the illness (i e the psychiatric symptoms) status or social level and adaptation, capacity for work and for pleasure and bad features Such a classification brings forward important items which are not evident in many follow up figures, though evident enough when reading an individual case record In group (a) the percentage relieved of symptoms was over twice that of group (c), but improvement under other headings was by no means proportionate Three quarters were relieved but one half had permanent impairment of their power of enjoyment (this does not refer to sexual pleasure) and bad features were present in three quarters The latter are personality changes which in group (c) might be residual psychotic traits, but in group (a) must be considered to be the result of leucotomy

Although many tens of thousands of these operations have been carried out, post mortem material is only slowly becoming available The most extensive studies of this material have been reported from the Maudsley Hospital by McLardy Meyer and Beck In their various papers the site and the extent of the operative lesion have been carefully documented, the consecutive distant lesions in the brain detected and mapped, and where adequate clinical records have been available the relation between therapeutic result and lesion has been analysed These painstaking studies have been rich in revelation, they have provided or confirmed anatomical data startled surgeons by the variability of the lesion nullified the notions and prejudices of certain theorists and shed light on some of the causes of death

A variable and quite uncertain factor in the standard leucotomy

point out that personality must be considered as the sum of the intellectual emotional energetic components of the individual, and that defects in the intellectual and in the emotional domain are essentially inseparable ' The intellectual equipment in the sense of past experience is undamaged but close examination discloses certain defects that become more obvious in cases of extensive incisions These defects are manifest as an inability to solve difficult problems to carry in the mind several items at once, to synthesize ideas and to foresee the result of a sequence of actions The capacity of an individual to project himself into the future is fundamentally disturbed in these patients This type of disturbance corresponds to Goldstein s (1949) impairment of the abstract attitude In a very illuminating and carefully documented study of patients undergoing leucotomy Partridge (1951) vividly portrays these finer intellectual changes which to formal tests may not be evident but are particularly noticeable within the family circle The lead to this social assessment was given by Rylander (1939) and demands long periods of time spent in interviews with a patient and his relatives In a total of 92 patients who recovered from their illness after leucotomy Partridge found an intellectual deficit of one sort or another in 54 most noticeable amongst those in the more highly skilled occupations

In the sphere of emotion the patient after leucotomy is freed from anxiety from a sense of tension and from any inferiority complex and fails to think critically of his own behaviour in society To some extent these changes are desirable for they are the aim of the surgeon but with them arise disturbances which when excessive prove most undesirable at any rate for society, though the patient may be undisturbed and well content These personality changes are revealed in a variety of ways a slowing of drive a preference to postpone action and a lack of initiative a flattening of the emotions combined with a happy go lucky attitude to life and euphoria a lack of restraint of word or behaviour which leads to remarks or situations embarrassing to others but not to the patient in the more extreme cases gross selfishness obstinacy and complete lack of awareness of their hopelessly unreasonable attitude Bursts of violent temper may occur which are quickly over and for which the patient shows no remorse Partridge reported that of 60 patients who recovered from affective disorders there were 17 who showed undesirable changes and in some of the others there were discernible changes of lesser degree

Improvement which continues for several years after operation is only to be expected if the opinion expressed by Frankl and

et al, 1948 Cort 1948), in the brains of the second group of cases characterized by nutritional or trophic deterioration the common link was found in a severe bilateral lesion of the region of the subcallosal fasciculus at the level of the head of the caudate nucleus Disturbances of water and electrolyte control at times associated with severe hypotension, and resulting from a variety of frontal lesions have been encountered by most neuro surgeons and reported by Allott (1939), Sweet *et al* (1948), Higgins *et al* (1951) and McCarty and Cooper (1951) In some of these cases the out standing feature has been a retention of chloride, and this may be due to dehydration or to diminished blood volume (Borst 1938 1951) Whether this be so or whether there is some intrinsic upset of the fronto hypothalamic hypophyseal adrenal mechanism is not yet evident The work of Harris (1950) le Gros Clark and Meyer (1950) amongst many others shows that anatomically and physio logically such a mechanism is feasible Certain it is, however that not only are leucotomy lesions placed in the posterior part of the frontal lobe liable to lead to the grossest of intellectual and personality changes but they are also liable to be fatal by reason of profound biochemical disturbances

A wider appreciation of the undesirable results which may follow what is nowadays conveniently called standard leucotomy has led to the development of alternative operations Choice has been achieved by way of a variety of arguments in which animal experi ment summarized by Fulton (1951) in his Salmon Memorial Lecture clinical observation analysis and theories based on cyto architectonics have each played a part

Some surgeons have thought that a more predictable and standard lesion would be obtained by performing leucotomy under direct vision The technique of open leucotomy was described by Lyerley in 1938 but has only gradually acquired some popularity large trephine openings are made one either side of the middle line in front of the coronal suture and under direct vision using a good head lamp or illuminated deep retractors the brain is divided with a narrow suction tip which can also be used for the endothermy of bleeding vessels Although the cut can be made as extensive as is deemed necessary in vertical and lateral directions there are no landmarks within the substance of the brain to indicate whether the cut is too anterior or too posterior, only a sense of direction neither more nor less accurate than that available to the experienced surgeon during the blind method Encroachment upon the tip of the frontal horn of the ventricle is of little help as its size and position may vary within normal limits and in a number of patients

is the relation of the plane of the cut to structures within the brain Rowland and Mettler (1948) have shown that the point of election for the trephine may overlie a point on the brain varying in different subjects up to 2 cm in antero posterior and in vertical directions Thus the operation commences with a margin of error of 2 cm Poppen believes that the plane of section must lie within a zone of 2 cm but Freeman states that the margin of error is only 2 mm yet he has no method of detecting such an error When the leucotome is made to traverse the brain substance according to its shape it will cleave easily or with difficulty The brain will be displaced within the cranium according to the roominess of the subarachnoid spaces—a shrunken brain tends to be displaced rather than to be cut compared with one that more closely fills the cranium This point was emphasized nearly ten years ago by Clarl Maxwell (1945) Variability in site and in extent of the cut is clearly proven in the post mortem studies by Meyer and McLardy (1949) They found the cut to fall within two planes which roughly define the middle one third of the middle frontal convolution, within these rough limits there is also much disparity in the direction which the cut takes relative to the plane of the coronal suture the extremes lying almost at right angles to one another Great diversity also occurs in the extent to which the lesion occupies the cross sectional extent of the brain Another unpredictable factor at the time of operation though evident enough in post mortem studies is the extent of the damage resulting from hæmorrhage thrombosis necrosis and œdema of the brain beyond the confines of the narrow slit like cavity produced by the surgeon s instrument Yakovlev Hamlin and Sweet (1950) show this particularly well in their post mortem specimens

It is convenient at this point to refer to certain metabolic complications which may follow leucotomy and other lesions of the brain In a series of 122 cases in which the brain was available McLardy (1950) found that post operative cerebral hæmorrhage had been the cause of death in 31 and in all these the period of survival did not exceed fourteen days In 22 patients death occurred within six months and these comprised two groups those dying in uræmia about the third week and those with progressive lethargy wasting cutaneous bullæ and ulceration dying between the second and fifth month In the specimens of the first group where there had been uræmia traumatic lesions were found in the posterior part of the orbital *cortex* It may be of significance that stimulation of this area in the experimental animal has produced vegetative disturbances and interference with kidney function (Livingstone

On the assumption that the therapeutic benefits of leucotomy are due to division of the thalamo frontal projection fibres which stream forth from the anterior limb of the internal capsule, incomplete leucotomy has been carried out, the inferior part only of the white matter of the frontal lobe being cut Fulton (1951) states that in Rylander's experience damage to fibres projecting on the lateral surface of the frontal cortex causes impairment of intelligence which is but little evident after inferior cuts Ablation of the posterior orbital cortex in monkeys is said to cause a great increase of motor activity (Livingstone *et al*, 1948), and the results of such experiments have been used as an argument for applying similar operations to overcome the passive withdrawn state of schizophrenia Thorpe and Hardman (1952) have found that "lower quadrant leucotomy" is therapeutically as effective as a full cut with less risk of urinary incontinence and easier rehabilitation In 147 patients discharged from hospital there was a relapse in 18 Egan (1949) reports a more thorough isolation of the orbital part of the frontal lobe the inferior quadrant cut is made and from the upper end of this another cut is made forward The most common post operative changes were restlessness and irritability, reminiscent of the ablation experiments on monkeys The cases included a majority of schizophrenics the duration of the illness averaging ten years and the proportion improved was roughly similar to that following the standard operation Personality changes occurred obsessional symptoms were less well relieved and relapse occurred in one fifth of all cases An alternative type of partial leucotomy has been described by Grantham (1951) in which through a burr hole placed near the midline only the medial part of the cut is made In order to improve accuracy the ventricle may be tapped and a small quantity of air injected radiograms taken while the patient is on the table will show more precisely the position of the instrument Recently he has employed endothermy for making the lesion Long term results are not yet available nor are there any published records of post mortem examinations, but the method seems worthy of extended trial

In 1944–45 Penfield carried out a series of tentative operations on 7 patients who were candidates for leucotomy, excising various symmetrical areas of frontal cortex within the zone which could be disconnected from the thalamus by the lobotomy procedure if necessary" The aim was to secure the therapeutic effect of a leucotomy (syn lobotomy) but preserving more of the function of the frontal lobe The position and size of the cortical ablations varied, some being entirely convexity between the tip of the pole

it may be pathologically enlarged (Donovan *et al* 1949) The post mortem evidence adduced by Yakovlev and his associates does not support the contention that the lesion of an open leucotomy is more concise than that of the blind *The zone or thickness of the lesion* was up to 20 mm where retraction and a sucker was used, and only up to 3 mm where a leucotome was employed A more restricted form of operation is that designed by McKissock (1951) and called *rostral* leucotomy Burr holes are made 2 cm from the middle line just in front of the coronal suture and the brain cut is made from this point in a plane passing through the junction of the anterior and middle one thirds of the roof of the orbit and about 2 cm in width This operation has been employed for non psychotic tension and affective states and considerable therapeutic effect is claimed with appreciably less personality change than with the standard leucotomy Detailed psychological records comparing *the results of the rostral and standard operations have been made by* Petrie (1952) Transorbital leucotomy has been devised by Freeman who acknowledges Siamberti as the originator A specially designed leucotome is inserted into the superior conjunctival fornix and driven through the roof of the orbit into the under surface of the frontal lobe By suitable traversing movements of the handle of the leucotome the white matter of the inferior part of the frontal lobe can be divided in the coronal plane to a depth of 7 cm from the supra orbital margin Further damage can be effected by making the ' deep frontal cut perpendicular to the coronal plane The method does not require the panoply of a major operation the fornix being considered to be usually sterile and it can be carried *out on a patient who has been rendered unconscious by an electric* shock Freeman (1951) has compared the results of the standard operation on 624 patients and the trans orbital operation on 312 patients In schizophrenia there was approximately the same percentage of good results though rather more patients were retained in hospital after the trans orbital operation In cases of affective and psychoneurotic disorder there were a greater number of good results after the transorbital operation and about the same percentage were in employment after both operations Epilepsy was much less frequent after the transorbital than after the standard operation It has not found many adherents, being even less precise than other methods and having a crude technique Edwards (1950) considered that it is followed by less personality changes and thinks it of value in agitated depressions and in neurosis but of no value in obsessional states which have lasted more than two or three years

Brodmann based it upon the examination of the chimpanzee's brain and then drew a similar pattern on the human brain. Not only are the areas conjectural but their estimation upon the human brain partially exposed by craniotomy can be but guess work conforming roughly to the larger areas. Their topographical registration on diagrams for record purposes and for application to further experience can also only be approximate by reason of the distortion due to the projection from a spheroidal to a plane surface. These limitations were recognized and accepted and the system adopted 'for the sake of convenience'. The estimated total weight of brain removed varied from about 10 to 75 gm; the specimens were subjected to histological examination in order to confirm or refute their presumed cytoarchitectural site.

A follow up of these patients and the reports of further studies have recently been published (1952) and the two volumes of the work of the Columbia Greystones Associates provide a mass of detailed information which cannot be summarized here though it is of the greatest value to those who study it closely. The criterion of improvement is discharge from hospital—not a satisfactory one but its adoption is defended by the authors. Of 23 undergoing topectomy 11 patients were out of hospital for two or more years after the operation, and of the controls 4 of 16 were out of hospital (without operation) and 3 of 8 who later underwent leucotomy were out of hospital. These bare statements cannot take into account the social status or rehabilitation of the patient. The conclusions which the Associates draw are very cautious: the discharge rate is greater in the operated than in the controls but this significance is obscured by certain variations in prognosis between groups, and although there was a correlation between improvement and the occurrence of the project and this might be due to operation, nevertheless it might be related to the situation. There were no obvious psychological or physiological enduring alterations and no permanent loss of intelligence, but there seemed to be a clear relation between social improvement and a decrease in anxiety and in complaint so far as these matters could be detected and measured by tests. Because of the grounds from which the operation was developed the following conclusion is important: that there was no evidence or cause to believe that recovery was necessarily related to ablations of areas 9 and 10. Hoch (1951) gives details of the results of topectomy in 105 patients comprising psychotics and non-psychotics, ill for several years and unrelieved by other forms of treatment; he pointed out that the results depended upon the degree of deterioration, a factor difficult of assessment. In those

and the coronal suture others extending on to the medial or orbital surfaces Penfield (1948) considered the results did not make the operation an acceptable substitute for leucotomy but drew the important conclusion that bilateral ablations of cortex in the postero superior part of the frontal convexity were the most likely to lead to intellectual deficit and ablations not including this area gave rise to little or none Psychiatric and psychological examinations of these 7 patients (Cameron and Prados 1948 Malmo 1948) revealed that in three more was gained than lost by deficit and in one of these the gain was considerable and that in all cases there was greater or less intelligence impairment but it was found impossible to correlate symptomatic improvement with localization of the lesion Epilepsy developed in 3 of the patients and 2 subsequently underwent leucotomy In 1948 Heath and Pool described the effects in 4 patients of bilateral ablations of part of the superior frontal convolution in 2 patients there was improvement of the mental state At the time of these operations Mettler was considering the need for an alternative operation to leucotomy and saw possible significance between the results he had obtained (1924) of removing Brodmann s area 9 in simians and the finding that the part of the dorso medial nucleus which most frequently showed degenerative changes after leucotomy is that which projects to area 9 namely that the critical factor in leucotomy might be the isolation of area 9 *From these beginnings* developed the co operative project of the Columbia Greystones Associates (1949) A series of 24 patients was subjected (much as in Penfield s smaller series) to operation in which pre selected portions of the frontal cortex were excised the operation being called topectomy 24 other patients were selected as controls All the patients were psychotics and all had been in the same hospital for an average of four years and had been given the common varieties of treatment Great care was exercised in order to match the patients in pairs and all were housed together so that the special attention commonly given to patients having an operation was also provided for the controls Extensive tests covering physical as well as mental functions were carried out before and after operation In 23 of the patients the portions of cortex excised corresponded to certain of the Brodmann areas in various combinations and as removal of some of these areas inevitably damages cortical veins emptying into the longitudinal sinus in one case no brain tissue was excised but these veins were ligated As the authors—and others—take pains to emphasize the application of the Brodmann cytoarchitectonic map to the human brain is an act of faith and of conjecture

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patients without deterioration there was good improvement in 60 per cent, but only in 7 per cent of those markedly deteriorated In 68 schizophrenics there was sufficient improvement to leave hospital in only 11 The anatomical site of ablation bore little relation to the clinical result In 1947, stimulated by the work of Pool similar operations were undertaken by Le Beau and in 1948 with Feld and Bouvet he set out the reasons why an approach to this problem on the basis of removing various Brodmann areas is preferable to leucotomy Later (1951) he has recounted the difficulties of assessing results these comprise the lack of precision in measuring mental impairment or improvement, the proportionate share to be assigned to spontaneous recovery the inability to decide the cytoarchitectonic field of the intact brain and the unpredictable degree of incidental lesions produced by hæmorrhage and ischæmia at a distance from the operation field He considers that in a psychosis it is necessary to remove some 20–25 gm of cortex on each side though there have been contradictory results when the operation was carried out for the relief of pain There were 6 deaths in 76 topectomies 23 of the operations were successful in relieving pain compared with 9 in which this end was not achieved and 11 successes and 13 failures in operations for neurosis and for psychosis

An important contribution to the surgical treatment of mental disorder has been made by the removal of the cingulate gyrus This is based on the observation that ablation of this part of the cortex in the monkey (Ward 1948) leads to a striking tameness of the animal Whether this is a result of the projection on to this area of fibres from the anterior thalamic nucleus which in turn receives the mamillo thalamic tract and thereby connections from the hypothalamus and hippocampus (le Gros Clark 1948) is not known Glees Cole, Whitty and Cairns (1950) carried out experiments on 7 monkeys making lesions in the anterior cingulate gyrus and confirmed the previous observations A continual restless pacing was also noticed in these animals as had been noted in animal experiments where other areas of frontal cortex had been removed The authors were impressed that so small a lesion could produce such marked behaviour changes they comment on the short duration of these changes and suggest that in the human even a temporary disturbance might allow of more fruitful psychotherapy In 1952 Whitty Duffield Tow and Cairns published the results of cingulectomy in 29 patients of whom 1 died In patients with a psychosis there was no worth while improvement but in 6 out of 8 other patients there was definite improvement and to such a degree

in 2 as to describe the illness as being cured These observers were impressed by the slightness of personality deterioration which they could detect Le Beau (1952) has also explored the effects of lesions in this area produced either by excision or by undercutting although in the latter case a wider area of the cortex of the medial surface of the hemisphere was damaged These operations were carried out in a variety of cases and the results in the non psychotic illnesses were much as in the Oxford series

Operations for the excision of portions of cerebral cortex demand an osteoplastic craniotomy which takes considerable time damage to blood vessels may affect a much wider area of cortex than is anticipated there may be a high potential risk of epilepsy The operation of cortical *undercutting* was introduced by Scoville (1949) as an alternative method of interfering with the function of selected areas of cortex, and at the same time of avoiding the disadvantages of ablation Three areas have been selected for isolation by this procedure the convexity cortex (corresponding approximately to Brodmann areas 9 and 10 and thus somewhat similar in location to rostral leucotomy) part of the medial surface of the frontal lobe including the cingulate gyrus, and the inferior or orbital surface of the frontal lobe as far back as the vicinity of the chiasmal cistern Access to the appropriate area of brain is obtained through large trephine holes and the cortex is undercut under direct vision for which good illumination is essential by means of suitably shaped retractors and fine suction instruments The total area of cortex thus isolated is from 50 to 60 square centimetres Scoville *et al* (1951) and Wilk (1951) have described the results of these operations on 150 patients and compared them with a series of leucotomy operations They find that each type of orbital undercutting gives as good a chance of improvement as leucotomy even in schizophrenia without however the same risk of personality change An immediate effect was noticeable following convexity undercutting as contrasted with cingulate undercutting in which the benefit was slow in showing itself This feature was noted by Cairns and his co workers in their cases of cingulectomy Scoville *et al* do not consider that there is any specificity in the area selected and quote the opinions of Busch Sjoquist and Rylander that no lowering of the intelligence quotient or disturbance of the abstract attitude follows orbital or superior surface undercuttings Epilepsy occurred in about 6 per cent of cases

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Operations for the excision of portions of cerebral cortex demand an osteoplastic craniotomy which takes considerable time damage to blood vessels may affect a much wider area of cortex than is anticipated there may be a high potential risk of epilepsy The operation of cortical *undercutting* was introduced by Scoville (1949) as an alternative method of interfering with the function of selected areas of cortex and at the same time of avoiding the disadvantages of ablation Three areas have been selected for isolation by this procedure the convexity cortex (corresponding approximately to Brodmann areas 9 and 10 and thus somewhat similar in location to rostral leucotomy) part of the medial surface of the frontal lobe including the cingulate gyrus and the inferior or orbital surface of the frontal lobe as far back as the vicinity of the chiasmal cistern Access to the appropriate area of brain is obtained through large trephine holes and the cortex is undercut under direct vision for which good illumination is essential by means of suitably shaped retractors and fine suction instruments The total area of cortex thus isolated is from 50 to 60 square centimetres Scoville *et al* (1951) and Wilk (1951) have described the results of these operations on 150 patients and compared them with a series of leucotomy operations They find that each type of orbital undercutting gives as good a chance of improvement as leucotomy even in schizophrenia without however the same risk of personality change An immediate effect was noticeable following convexity undercutting as contrasted with cingulate undercutting in which the benefit was slow in showing itself This feature was noted by Cairns and his co workers in their cases of cingulectomy Scoville *et al* do not consider that there is any specificity in the area selected and quote the opinions of Busch Sjoquist and Rylander that no lowering of the intelligence quotient or disturbance of the abstract attitude follows orbital or superior surface undercuttings Epilepsy occurred in about 6 per cent of cases

Other types of operation have been recommended for the relief of mental illness but only one is of sufficient importance to warrant description A stereotaxic technique has been devised by Spiegel

and Wycis based on that of Horsley and Clarke by which lesions are made within the thalamus itself so as to damage selected groups of nerve cells The technique and apparatus have necessitated much study of anatomical structures and relations because the accurate placement of the desired lesion is based upon reference by measurement within the patient's skull to the pineal gland If this structure is not sufficiently calcified to be visible on an X ray film encephalography is carried out in order to visualize the supra pineal recess or other identifiable structure of the third ventricle The apparatus is a complicated piece of precision engineering and with the technique and the necessary brain atlas is fully described by Spiegel and Wycis in Stereo encephalotomy (1952) The lesions may be made by electrolysis or by electro coagulation although the accuracy with which they can be placed has been questioned but the post mortem evidence provided by the illustrations of the brains of 4 cases published in their volume is impressive These methods are as yet in a tentative stage so far as human surgery is concerned though they have been used for many years in animal experiments and found reliable They are more time consuming than other procedures but are likely to become less so as experience grows It is a technique which may be increasingly adopted for those forms of cerebral surgery in which deeply placed precise and limited lesions need to be inflicted The results of the operation in 56 patients are described by Spiegel and Freed (1951) 79 operations were carried out with 2 deaths Bilateral lesions were made (*a*) in the dorso medial nucleus (*b*) in the anterior nucleus of the thalamus (*c*) in the lateral part of the posterior hypothalamus The mental disorders were mainly schizophrenia 25 per cent of the patients returned home working to a greater or less degree and 25 per cent were more easily manageable but were retained in hospital In no patient was there marked disturbance of personality and in only one did epilepsy develop Following this lead stereotaxic methods have been explored by others Talairach *et al* (1949) use a grid projected upon the air filled ventricle and seen in an X ray film as a device for localization Lelsel (1949) places an electrolytic lesion just anterior to the anterior limb of the internal capsule roughly in the site of the standard leucotomy incision but of much smaller extent

Conclusions

A massive literature has emerged in the last decade devoted to the cerebral surgery of mental illness and the busy surgeon fully occupied with other operations on the nervous system can hardly

hope to cover it. In this review only the seemingly more important articles are mentioned and doubtless many others have been missed. But no neurosurgeon worthy of the name however busy he may be will wish to embark on these operations which carry such grave responsibilities for the patient and for the community as a whole without serious meditation. In other branches of his work he is confronted with tangible pathological lesions which more often than not if untreated will lead to the patient's death. His aim is usually quite clear cut and simple and the risks of operation measurable by the obvious criteria of the mortality rate and of disability due to some neurological deficit. When he applies his activities in the field of mental illness all the normal criteria are absent. Mortality rate is relatively low at any rate in certain operations; the degree of skill which he may appear to need or to exert is so slight that a particular operation may gain adherents because so many can be performed within the hour. On the other hand he can choose an operation lasting several hours and demanding the patience and endurance of any other major craniotomy and carrying the same post operative complications. He will work in a field in which by contrast with his more usual one there are no objective neurological abnormalities and in which the illness is described in a technical jargon which to him may at first be unintelligible—and thereby may acquire a false importance for him—and usually remains partly so. He is endeavouring to relieve by a would be rational organic method an illness which has no proven pathological lesion. Finally and probably this is the most important burden for his sense of responsibility he finds his operations often unpredictable in the extent to which they alleviate mental suffering and when they do give relief the unfortunate's personality may be so changed that the relatives object to having him home; if he reaches home subtle changes in the personality may still be sufficient to reduce "drive" so as to make him unemployable. In this as in his other fields of work the neurosurgeon has his pleasant surprises which compensate for disappointment and tempt him to persevere.

It is now well established by experience that a wide variety of operations on the frontal lobe—and indeed on other parts of the brain—will in certain cases of mental disorder greatly relieve symptoms. Such successful results occur with regularity and considerable frequency in those non psychotic conditions manifesting tension, anxiety and agitation and the syndromes described as compulsion, obsession and rumination; and in the affective disturbances of depression and of melancholia. In the psychoses particularly schizophrenia provided the illness is not of

too long a duration and the personality not too disintegrated, improvement may less frequently occur and on occasion to a totally unexpected degree Such improvement then seems to be the result of destroying or diminishing an element of tension in the patient s mind and invoking such a degree of temporary dissolution or disturbance of the personality as to allow a new pattern of behaviour to be built up by appropriate rehabilitation If relapse occurs it *takes on a pattern similar to that which characterized the original* illness In every case the operation is only one part of the treat ment recovery and maintenance of recovery depend largely on a satisfactory environment Return to that environment in which the original breakdown *occurred* invites relapse

Do we yet know the anatomico physiological basis of these operations and which is preferable in any particular case ? Clinical experience with leucotomy has made it clear that its effects are the more pronounced the more extensive and the further posterior the lesion happens to be And *pari passu* the undesirable effects may then predominate There is some evidence though not fully supported by anatomical studies that partial inferior and partial medial cuts can be as beneficial as total cuts with less undesirable qualities but to these lesions no more precise term can be applied than partial which of itself gives by anatomical standards but a vague approximation of location and of extent The so called selective operations of ablation and of undercutting are more precise in the sense that the extent of the lesion and its placement are more under the control of the surgeon but not fully so because of *distant effects resulting from the disturbance of blood supply* and from bruising Critical assessment of the results of these operations is made difficult by the varying criteria of improvement and in some papers by the lack of detailed long term follow up But it seems likely that all such operations may have broadly similar *results that none is as drastic as the standard leucotomy and* yet they may give as good results in patients with non psychotic illness with less personality damage and less impairment of abstract intelligence The most restricted lesion giving reliable benefit seems to be cingulectomy though time may show that the small *deep lesion produced stereotaxically may prove as beneficial* Like partial and anterior leucotomy these operations appear to give less enduring benefit in schizophrenics

The application of the results of animal experiments to this branch of surgery has been fruitful in so far as it has stimulated the variety of form of operation But direct comparison of the effects of frontal lobe operations on animal performance with operations

on the human brain for mental disturbance are unimpressive and indeed ludicrous. The would-be basis of much of the surgery is cytoarchitectonic, of the value and reliability of which there is considerable doubt. Certain it is that any operation based on ablation of particular 'areas' must not be given for that reason a scientific cachet. The papers of Lashley and Clark (1946), Bailey (1950) and Le Gros Clark (1952) make it clear that excessive cyto-architectonic parcellation of the frontal cortex can no longer be maintained as anatomically sound. Beck, McLardy and Meyer (1950) have demonstrated the great variability in the extent of the granular frontal cortex on either side of the brain and from subject to subject and state that no claim to remove particular areas is valid. Contradictory results abound, so conflicting that at times one hesitates to accept any certain anatomical basis for the operation and this reminds us of its essential empiricism. McGrath (1951) reports the case of a woman with paranoid schizophrenia treated by leucotomy with such success that she was considered to have recovered and she earned her living. She died five years after the operation as the result of coronary thrombosis. The leucotomy lesions occupied most of the central and lateral parts of the white matter at the plane of the tip of the caudate nucleus involving much of the anterior thalamic radiations to the convexity frontal cortex; extensive retrograde degeneration was found in certain thalamic nuclei. McGrath considered that this case confirmed the view widely held that there is a quantitative relationship between benefit and the isolation of frontal cortex from thalamic connections. On the other hand McLardy and Davis (1949) reported the extent of the lesion in relapsed cases, thereby putting on record that psychotic illness can recur after virtually complete isolation of frontal cortex and even bilateral lobectomy. Neurotic symptoms may recur after lesser lesions. Analysis of the lesions of leucotomy by Meyer and McLardy (1949) has shown that the 'central' segment of the cross-section of the frontal lobe is the most frequently damaged in cases showing improvement and the ventral, dorsal and the cingulate segments with diminishing frequency. So far as they could judge there was no evidence that localization of faculties occurred in the prefrontal region and the beneficial effects ran parallel with the size of the lesion. There was no support for the contention that orbital lesions lead to euphoria and dorsal ones to apathy. It is probable that cutting the central segment of white matter is important for the reason that here the thalamic projection fibres are fanning out; it is a strategically potent area. Although there appears to be this quantitative relationship

between cross sectional extent of the lesion and clinical benefit, its position in the antero posterior direction must also be borne in mind there is a three dimensional relationship It is this which may account for unexpected benefits following minimal lesions, reported by Meyer and Beck (1945) in their first paper One recalls also the experience of the Columbia Greystones Associates of the need for carrying controls who sustain the same intense interest as the patients operated upon

Leucotomy still maintains its position as the operation likely to achieve most benefit in cases of schizophrenia and there is a place for repeating the operation making the cut in a more posterior plane where a previous less drastic operation has failed For the various tension neurotic states a choice of operations is available all having proved of some value and of which cingulectomy and orbital undercutting seem at present the most useful Stereotaxic lesions may prove to be the most selective in the anatomical sense but the complicated techniques at present limit the application of these operations In every patient in whom operation is under consideration the surgeon should have an assurance that all alternative treatments have been tried and have failed or are at any rate unsuitable and that spontaneous improvement is not to be expected He should realize that his operation is still an empirical one—a coarse weapon with which to attack the maladjustments of humanity s most recently acquired and delicate attributes he must eschew pseudo scientific jargon and explanations which merely veil our ignorance In assessing the results not only must due attention be paid to the relief of symptoms but also to the cost to the patient by loss of personality of abstract thinking and of the power of human enjoyment Although much benefit may follow operation epilepsy is a sequel in an appreciable number of cases least likely to occur following stereotaxic lesions and probably most frequent after ablation of cortex

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CHAPTER XXXI

THE SURGICAL TREATMENT OF EPILEPSY

EPILEPSY has been an attractive subject to surgeons throughout the ages and indeed until the era of MacEwen, Godlee and Horsley cases of head injury and of epilepsy comprised the chief material for cranial operations. Although isolated reports of "successful" operations for epilepsy are available in the early literature, such definitive operations on the closed cranium relied for localization upon the evidence of a scar, or of a depression in the bone. But, in common with all forms of surgery, there was a heavy mortality as a result of wound infection. The latter part of the last century saw the enunciation and acceptance of the principles of cerebral localization and the development of aseptic surgery; thereafter modern neurosurgery began rapidly to evolve. In the first quarter of this century surgeons largely confined their activities to the successful extirpation of intracranial tumours and other space occupying lesions, and to the study of the natural history of these lesions and to the problems of intracranial hydrodynamics. These were urgent matters needing priority and consequently interest in epilepsy as a surgical subject waned except in so far as it was symptomatic of an expanding lesion. The results of such operations for epilepsy as were occasionally reported were not encouraging, thus further persuading the neurosurgeon to direct his attentions to a more rewarding field. In 1921 Penfield commenced a study of the healing of experimental brain wounds and later extended this to a series of brain scars from cases of traumatic epilepsy derived from the clinic of Foerster. Since that time there has been a steady growth of knowledge concerning the mechanisms of epilepsy and its surgical treatment and most of the credit for these advances must go to Penfield. Not only has he supplied a great stimulus in this field but his observations on the various cerebral lesions and on the neuro physiology of the cortex exposed in patients under a local anæsthetic have been of the greatest value. In recent years the introduction of certain ancillary methods of investigation has added a further impetus to this expanding field. Encephalography and ventriculography can demonstrate local or general atrophy of the brain; angiography has made it possible to reveal radiographically the presence of unsuspected vascular abnormalities and electroencephalography has provided a method of distinguishing certain varieties of epilepsy

and of accurately localizing and defining areas of cortical discharge'

The indications for operation comprise the establishment of a focal origin of the seizure and of its location the demonstration of its accessibility for surgical removal without undue residual disability the diagnosis of the pathological nature of the lesion, which however may often be a matter of conjecture the failure of medical treatment

Classification of the type of seizure depends primarily upon a study of its pattern This demands a careful enquiry of the patient and of reliable witnesses of attacks The various focal attacks which may occur cannot be listed here they are to be found in current textbooks of neurology and are exhaustively discussed by Penfield and Erickson (1941) Of particular importance is the initial disturbance or aura which Penfield considers to be of the greatest localizing value Kristiansen (1949) analysed 222 cases of focal cerebral seizures from Penfield's clinic in which the localization of the focus had been studied before and during operation and compiled the following table

Initial Phenomenon in 222 Cases of Focal Cerebral Seizures

	per cent
Unconsciousness	14
Motor (Jacksonian adversive)	13
Somatic sensory	25
Visual auditory etc	12
Autonomic (mainly abdominal aura)	12
Psychical (including hallucinations and illusions)	13
Miscellaneous	11

The significance for localization of the study of the seizure pattern is clearly dependant upon our knowledge of the function of the various areas of the cerebral cortex and it is in this field that *Penfield and his associates have made such contributions* Observations upon the effects of stimulating the cortex on patients under a local anæsthetic and the results of cortical ablation have recently been recorded by Penfield and Rasmussen (1950)

Little need be said here of the necessity for careful radiological examination Simple films of the skull and air encephalograms are necessary to exclude—or to identify—tumours calcified intracerebral lesions and to demonstrate the presence and extent of brain atrophy In chosen cases angiography will be of value in elucidating the pathological nature of the epileptogenic lesion

The electroencephalogram (E E G) can provide information of the greatest assistance in classifying the type of seizure and in localizing a focus of discharge. A scar, a rapidly growing tumour, a cyst or an abscess is electrically inactive and where such a lesion is sufficiently large and close to or replacing the cortex the records taken with scalp electrodes may bear witness to a diminution or an abnormality of activity. Porencephalic cysts and subdural haematoma in particular reduce activity. Abnormal electrical rhythms may arise from imperfectly functioning nerve cells bordering the lesion or involved in it and it is in these records that the characteristics of an epileptic E E G are found. The shape, frequency and distribution of the abnormal wave forms provide the information on which classification can be made. A limit to the accuracy of localization of the abnormal focus is imposed by the distance which separates the scalp electrodes from the cortex, a distance varying in different persons from 10 to 15 mm. By using multiple scalp electrodes feeding a multi channel recording apparatus the surface of the head can be charted in areas of about 3 cm diameter. Pharyngeal, tympanic and sphenoidal leads aid the investigation of the basal surface of the cerebrum. These records provide adequate localization for diagnosis and for the planning of a craniotomy. Precision can be obtained later by placing electrodes on the exposed surface of the brain, such a record being called an electro corticogram (E Co G). Localized cortical foci of discharge produce a localized abnormality of the E E G. If the focus is derived from deep structures and particularly when contained in the temporal lobe the abnormalities may be bilateral. The activity in the opposite hemisphere may be seen to develop in the course of several months of observation but the original focus commonly gives the greater abnormality. It is impracticable and out of place to describe here the varieties of E E G which occur in epilepsy; these are found in the writings of Penfield and Erickson, Jasper (1949), Hill and Parr (1950) and others. The most reliable E E G abnormality in focal epilepsy is the appearance at random intervals of the form of wave called a "spike". Its name fully describes its shape, there being a sudden large alteration of electrical potential (100–150 micro volts) of transient duration (10–40 milliseconds). A variant of the spike, the result of its being conducted over a greater distance (Jasper 1949), is the "sharp wave" which has a broader base lasting from 50 to 100 milliseconds. They may be random occurrences or there may be runs of up to six per second. Occasionally runs of delta rhythm (two to three per second) and of sharp waves at ten per second may occur. Jasper and Kershmann (1949) emphasize the

great variety of localized wave form which has been encountered in epileptic patients in whom cortical lesions have subsequently been identified It is possible that in some cases secondary thalamic disturbances have occurred some observations in support of such changes in "focal epilepsy and their significance in explaining unsuccessful operations are made by Myers *et al* (1950) If the E E G shows no abnormality the examination should be repeated under conditions which will help to bring out a latent abnormality Such activation ' may be achieved by inducing sleep with seconal or by intravenous injection of metrazol Jasper and Penfield (1948) found a focal E E G abnormality in 90 per cent of their cases of traumatic epilepsy and in 70 per cent the record showed spikes or sharp waves Walker (1949) gives a lower estimate (70 per cent) of the incidence of localized E E G abnormality in post traumatic epilepsy Penfield and Steelman (1947) found that in 59 cases of focal epilepsy in which the lesion was excised the E E G showed a simple spike or sharp wave focus only in 21, and a similar focus but with contralateral transmission in 16

The aim of operation is to remove the epileptic focus and where evident the pathological lesion According to the area of cortex involved this resection may permissibly be radical so as to include a bordering zone of apparently healthy tissue in other parts of the brain the resection must necessarily be restricted to a minimum Local anæsthesia is preferable so that the patient can help by describing his sensations but sometimes it may be necessary to carry out the operation under a general anæsthetic and satisfactory electrical recording can be obtained if pentothal is used Or the operation may be divided into two stages a general anæsthetic being used for the cutting of the flap and on a subsequent day the wound can be reopened under local anæsthesia for the cortical procedure In cases of healed compound fracture when scar tissue may unite the scalp the edges of the bone defect and the brain special care must be taken during the dissection of the several layers to avoid damaging the underlying brain by traction Where the exposed cortex includes the motor area it is usual to identify this by stimulating it with a suitable current Walker (1949) points out that if a scar is present in the vicinity of the motor cortex there may be difficulty in identifying the latter by stimulation owing to its having been damaged at the time of the original injury and that this difficulty lessens the longer the operation is delayed after the injury Care should be taken to use a minimal stimulus in order to avoid provoking a generalized seizure, which may so depress cortical activity as to prevent further satisfactory study

great variety of localized wave form which has been encountered in epileptic patients in whom cortical lesions have subsequently been identified It is possible that in some cases secondary thalamic disturbances have occurred some observations in support of such changes in "focal epilepsy" and their significance in explaining unsuccessful operations are made by Myers *et al* (1950) If the E E G shows no abnormality the examination should be repeated under conditions which will help to bring out a latent abnormality Such "activation" may be achieved by inducing sleep with seconal or by intravenous injection of metrazol Jasper and Penfield (1948) found a focal E E G abnormality in 90 per cent of their cases of traumatic epilepsy and in 70 per cent the record showed spikes or sharp waves Walker (1949) gives a lower estimate (70 per cent) of the incidence of localized E E G abnormality in post traumatic epilepsy Penfield and Steelman (1947) found that in 59 cases of focal epilepsy in which the lesion was excised the E E G showed a simple spike or sharp wave focus only in 21 and a similar focus but with contralateral transmission in 16

The aim of operation is to remove the epileptic focus and where evident the pathological lesion According to the area of cortex involved this resection may permissibly be radical so as to include a bordering zone of apparently healthy tissue in other parts of the brain the resection must necessarily be restricted to a minimum Local anæsthesia is preferable so that the patient can help by describing his sensations but sometimes it may be necessary to carry out the operation under a general anæsthetic and satisfactory electrical recording can be obtained if pentothal is used Or the operation may be divided into two stages a general anæsthetic being used for the cutting of the flap and on a subsequent day the wound can be reopened under local anæsthesia for the cortical procedure In cases of healed compound fracture when scar tissue may unite the scalp the edges of the bone defect and the brain special care must be taken during the dissection of the several layers to avoid damaging the underlying brain by traction Where the exposed cortex includes the motor area it is usual to identify this by stimulating it with a suitable current Walker (1949) points out that if a scar is present in the vicinity of the motor cortex there may be difficulty in identifying the latter by stimulation, owing to its having been damaged at the time of the original injury and that this difficulty lessens the longer the operation is delayed after the injury Care should be taken to use a minimal stimulus in order to avoid provoking a generalized seizure which may so depress cortical activity as to prevent further satisfactory study

drugs are given after the operation and should be continued for several years

The detailed results of operation for focal epilepsy on 165 patients have been given by Penfield and Erickson (1941) there were 7 deaths and 3 patients could not be traced In 35 no cortical extirpation was carried out Of the remaining 115 patients nearly one half remained free from attacks for the period of follow up (one to ten years) or had had not more than two seizures In about 30 per cent there was either no change or only slight improvement The percentage of improved cases showed a slight fall during the first two or three years after operation but then remained steady It was found in the cases of meningo cerebral scars that the results were more likely to be favourable if these scars were in the frontal lobe, and least so if they were in the sensori motor and parietal regions Duration of the lesion did not appear to have any influence on the result In a later series of patients (Penfield and Steelman, 1947) the results were rather better, 55 per cent of cases were cured or greatly improved by the operation The best results were obtained in cases in which the lesion was attributable to birth injury Recurrence of attacks in the immediate post operative period usually meant an unsuccessful result and where they were of precisely similar pattern to the pre operative attacks further operation was often carried out and the ultimate result was sometimes successful A different pattern of attack indicates that neighbouring gyri have been affected by the trauma of the resection, perhaps as a result of œdema or anoxia In Walker s series of cases of post traumatic epilepsy (1949), after one year 19 patients had been free—or had had an aura or only one attack, out of 36 The results of operation for cranio cerebral scars and other traumatic brain lesions have also been published by de Vet (1949) The post operative E E G is of considerable value in prognosis, for the persistence of spike discharge makes success unlikely and Penfield considers that in certain cases a further operation might be advisable for this reason alone

Temporal Lobe Epilepsy

The treatment of seizures arising in the temporal lobe is assuming sufficient importance to warrant special comment According to Bailey and Gibbs (1951) seizures of this type constitute one third of all cases of adult epilepsy The characteristic patterns of these attacks and their association with lesions of the temporal lobe have been recognized since the writings of Hughlings Jackson and indeed no better description can be given than his of a doctor who suffered

spaced over the field in order to obtain a rough indication of the whereabouts of the spike discharge The electrodes are then concentrated in that area in order to obtain as accurate a localization as possible If spontaneous spike discharge is absent, it may sometimes be induced by electrical stimulation of various points on the cortex for short periods of up to five seconds, repeated at intervals of a minute The effect on the E Co G is carefully observed and the patient questioned as to any subjective phenomena and any muscular responses are noted There is frequently a brief after discharge of spikes lasting a few seconds which may be considered physiological, but when the abnormal focus discharges this will be seen as a burst of spikes lasting many seconds up to several minutes *If when a given point is stimulated there is after discharge from the* focal electrode and the patient describes the aura of an attack this area is to be regarded with fair certainty as the excitable focus Walker found that in some 15 per cent of cases the after discharge occurred at a distance of up to 3 cm from the point of stimulation, in such situations it may be difficult to decide which portion of brain should be excised Other anomalies and difficulties are encountered and in particular with regard to the extent of the proposed ablation and the importance of multiple electrical foci, some of these matters have been discussed by Jasper (1949) and Walker (1949) The extent of the resection depends on the nature of the lesion (if visible) and the position and the extent of the epileptic focus It was the practise of Foerster to resect an extensive meningo cerebral cicatrix down to and including the wall of the ventricle Penfield and Walker doubt the necessity of doing this and believe it better to preserve the wall of the ventricle and thereby prevent blood and exudate from entering the ventricle where they may spread so as to give rise to an aseptic meningitis In addition to any obvious lesion the resection must include the epileptogenic focus as revealed by tests even though the brain appears superficially normal *In a so called silent area, such removal may be generous*—but where contiguous with eloquent areas the ablation must be sufficient but sparing In this case it is adequate to remove the whole width of the affected gyrus from the depth of one sulcus to that of its neighbour including the sub cortical white matter No cortex should be left denuded of its pial covering for this carries its blood supply and this may be ensured by restricting the use of endothermy and by leaving a fringe of free pia overhanging the margin of the cavity Small ablations can be effected by sub pial suction. A further E Co G is now carried out to detect any residual or fresh abnormal foci which should be removed Anti convulsant

by stimulation Most surgeons perform a partial lobectomy because gyrectomy has proved to be inadequate It should extend deeply to include the uncus and as far posteriorly as the test indicates but the extent must be governed by the need to avoid unnecessary risk to the integrity of speech and vision A careful description of the anatomy of the temporal lobe in respect of this operation has been made by Penfield and Baldwin (1952) Guillaume, Mazars and Mazars (1953) do not perform a formal lobectomy, but conserve the central white matter of the lobe in order to diminish the risk and extent of hemianopia By repeated cortical extirpations followed by E Co G examination, they extend the resection of grey matter until spikes are abolished paying attention to the preservation of speech In their series of 83 cases the middle or posterior part of the superficial temporal cortex was removed in 9, the lobe anterior to the vein of Labbé in 33, the same area with part or total corticectomy of the insula in 24 and with part or total resection of the hippocampus in 14 Krayenbuhl, Hess and Weber (1953) did not find a strictly localized focus of abnormality in their cases but rather a widespread abnormality of the temporal lobe though maximal in the anterior part The lesions which may be found are mostly those resulting from ischaemia, and occasionally neoplasms Earle Baldwin and Penfield (1953) found that in two thirds of their cases birth injury of the brain might well have caused the lesion , a frequent finding was gliosis of the uncus and hippocampus and the nearby cortex such as would result from temporary herniation of the temporal lobe through the tentorial hiatus during birth

The results of operation for temporal lobe epilepsy are perhaps slightly better than those for focal epilepsy elsewhere Penfield and Flanigan found that of 51 patients who were under observation for periods of one to ten years after operation, 27 had experienced no attacks or only one or two and in a further 13 the attacks had been considerably lessened Guillaume *et al* (1953) report 70 per cent of 72 patients free from attacks during a follow up of from six months to fifty months But Krayenbuhl *et al* (1953) consider that recurrences are likely to occur with the lapse of time The mortality of the operation is very low, there being only one death in Penfield s series of 75 operations and this has been the experience of other surgeons

Hemispherectomy

Infantile hemiplegia may result from a variety of pathological conditions in some instances the paralysis becomes manifest shortly after birth, sometimes it develops in a previously healthy

from them from the age of twenty until his death twenty three years later The symptoms included dreamy states (intellectual aura), masticatory and tasting movements, feelings of dread and automatisms, post mortem examination revealed a patch of softening in the left uncinate gyrus The dreamy state was elaborated by Gowers who called attention to other illusions of perception, and more recently Penfield s studies have made clear the diagnostic value of these abnormal states of consciousness Memory of the event is lost, the patient is not responsive in a co operative manner and indeed may react violently to any forceful control The automatism or mental confusion may have unfortunate medico legal consequences for as Hughlings Jackson said actions may occur of a kind which in a man fully himself would be criminal ' Because of such behaviour these patients are frequently referred to mental hospitals for treatment (Liddell 1953) Radiography of the skull may be helpful because a birth injury which may affect the temporal lobe may also give rise to a smaller hemi cranium on that side and abnormalities in the air encephalogram are present on the side of the lesion in nearly half these cases (Penfield and Flanigan, 1950) Electroencephalography will differentiate the true temporal lobe seizure from *petit mal* and from lesions in the frontal lobe in which automatisms may also occur The recording of random spikes from either temporal lobe is the important abnormality, this may be bilateral but it is important to determine on which side they predominate In 25 cases reported by Bailey and Gibbs (1951) an anterior temporal focus of spikes occurred unilaterally or predominantly so in 18 Interpretation of the E E G in cases of *suspected temporal lobe epilepsy and of psychopathic disorders* may be difficult Strict assessment of the clinical picture is necessary because the behaviour disorders of psychopaths may be mistaken for the automatisms of psycho motor epilepsy (Stafford Clark and Taylor 1949 Rey Pond and Evans 1949)

When the cortex is exposed by craniotomy electrocorticography is employed as in other forms of epilepsy and sometimes electrodes passed into or under the temporal pole may be necessary to identify a focus in a deep structure such as the hippocampus the focus is however, commonly in the anterior part of the lobe (Green Duisberg McGrath 1951) Cortical stimulation should be carried out if necessary to activate the E Co G, and to evoke the seizure aura Although in the non epileptic brain the temporal lobe may be regarded as silent Penfield has shown that after the temporal cortex has been prepared by the conditioning influence of epileptic discharges, elaborate psychical processes may be activated

to adjudge results The 3 patients reported by Cairns had no fits during the year which had elapsed after operation In McKissock's series of 18 patients there have been no further fits in two thirds Obrador (1953) reported 6 cases with 2 deaths, the results in the survivors were encouraging, but only 1 patient has been entirely free of fits

An unexpected and astonishing effect in many cases has been the remarkable improvement in the mental state and in the behaviour of these patients Such features as episodes of bad temper and asocial behaviour have improved and mental retardation has been relieved so that education became practicable and fruitful The benefits in this sphere have been so convincing that hemispherectomy may be considered for these symptoms even in the absence of epilepsy Another unexpected result of the operation has been to improve rather than to diminish the function of the hemiplegic limbs Although in a few cases there has been a transient post operative increase of weakness this phase has rapidly faded leaving the limbs with the same degree of limited voluntary control, but with a lessening or abolition of athetoid movement and in some with a sufficient lessening of spasticity as to make the limbs more useful Welch and Penfield (1950) have noticed similar effects following the removal of atrophic sensori motor cortex for focal epilepsy But they point out that in the present state of our knowledge such an operation cannot be advocated for the relief of spasticity In patients old enough for accurate sensory testing some relative impairment is usually found After operation this may be further impaired but in the final result appears to be but a relative loss A contralateral homonymous hemianopia is the constant sequel of the operation but is of little disability Speech disturbance after operation has not occurred in cases in which the hemiplegia developed before the acquisition of speech in these patients presumably the healthy hemisphere becomes the site of the speech mechanism Where the primary cerebral disease develops in the dominant hemisphere after the patient learns to speak it may be advisable to carry out preliminary testing of the situation of the speech centre by procainization of the appropriate area of the cortex

From the detailed descriptions of the brain exposed by operation it is clear that frequently the abnormal tissue is limited to a part of the hemisphere and it may be asked whether such a drastically extensive resection is necessary May not the healthy part be retained? Guided by his great experience of cortical ablation for focal epilepsy Penfield (1952) considers that complete hemispherectomy is rarely necessary, provided that all "nociferous" cortex is

infant during an acute illness diagnosed as encephalitis or the hemiplegia may have an abrupt onset similar to that of a vascular lesion in adults A proportion of these children subsequently develop severe fits and often behave abnormally In the course of an exploratory craniotomy undertaken to excise the epileptic focus in such a patient Krynauw in 1945 was led to remove the whole of the diseased cortex of one cerebral hemisphere owing to the widely spread abnormality shown in the E Co G The result of this radical measure was so encouraging that further patients were similarly treated and have been fully reported (1950) Focal and generalized seizures *petit mal* and psychomotor equivalents were observed The abnormal mental states have included retardation, uneducability and outbursts of temper (tantrums) in some cases so severe as to necessitate admission to an institution Radiological examination of the skull commonly reveals a smaller hemicranium on the side of the diseased hemisphere and air encephalography demonstrates the features of cerebral atrophy which may also be present to a lesser degree on the unaffected side of the brain Angiography may show vascular occlusion to a varying degree The E E G is markedly abnormal on both sides but predominantly so over the affected hemisphere

The operation is carried out through a large lateral osteoplastic craniotomy owing to the enlargement of the ventricle which when opened allows the hemisphere to collapse the operation of hemispherectomy is not technically so difficult as it might appear in contrast with hemispherectomy for tumour Details of the operation are to be found in Krynauw s article and in a report on three patients by Cairns and Davidson (1951) Although called hemispherectomy the term is somewhat inaccurate as the basal ganglia are preserved indeed it is of great importance that their blood supply be not damaged A wide variety of gross abnormality of the brain has been encountered diffuse atrophy and great thinning of the cortex localized porencephaly microgyria superficial atrophy and cysts underlying thickened opaque arachnoid McKissock (1953) has found the commonest abnormality to be cystic degeneration around the Sylvian fissure bordered by convolutions which are hard irregular and narrow Such pathological changes are the end results of processes which may be infective traumatic or ischæmic

The results of the published cases show remarkable success in abolishing fits All except 1 of the first 9 of Krynauw s series had convulsive seizures 1 died following the operation and the others have had no recurrence of fits his later cases are too recent

CHAPTER XXXII

INTRACRANIAL ANEURYSMS AND VASCULAR MALFORMATIONS

Aneurysms

THE connection between spontaneous subarachnoid hæmorrhage and cerebral aneurysms has become widely recognized since Symonds drew attention to it in 1924 but it is less well appreciated that aneurysmal rupture as a cause for hæmorrhage should be considered in the older as well as in the younger patient In their review of intracranial aneurysms McDonald and Korb (1939) found that more than half the patients were over forty years of age and in a series of 250 consecutive cases of death due to ruptured aneurysm, approximately half occurred between the ages of fifty and sixty nine years (Dinning and Falconer 1953) The ruptured aneurysm may inject its blood direct into the subarachnoid space, or if it be partly or fully embedded in brain the hæmorrhage may in the first instance be entirely intracerebral, subsequently breaking through into the ventricle and thus reaching the subarachnoid pathway This occurs in about half the cases of aneurysmal rupture and is very probable if the hæmorrhage causes loss of consciousness It is the rule for a hamartoma to rupture in this manner particularly as it is commonly of wedge shape, its apex reaching to the ventricle It is a much less frequent cause of bleeding than aneurysm in a series of 55 autopsies Hyland (1950) reported that a ruptured aneurysm was found in 44, a hamartoma in 2 and no local cause in 9 A rather higher incidence was reported by Small Holmes and Connolly (1953) The clinical manifestations of these lesions have recently been reviewed by Hamby (1952), MacKenzie (1953) and Meadows (1951) who also give extensive bibliographies

The ætiology and pathology of intracranial aneurysms have a bearing on their treatment Mycotic aneurysms which are most commonly caused by bacterial endocarditis do not call for surgery, although now that the use of antibiotics has greatly improved the prognosis of this disease the evacuation of an intracerebral hæmatoma is occasionally necessary Fusiform aneurysms are rare but may occur on the internal carotid and basilar arteries They are atheromatous in origin, the vessel being diffusely affected, and it

removed Krynauw found that the E E G was abnormal in areas of cortex far removed from the pathological area, and this induced him to remove the whole hemisphere and the abnormalities of the E E G of the other hemisphere often improved later In his tenth case a partial operation was first performed initial success was followed by a recurrence of seizures and hemispherectomy was then carried out but the late result is not yet known Obrador also found that limited operation was disappointing It is clear that further experience with much longer periods of post operative observation will be necessary before this question can be answered

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congenital malformations in these patients, in particular variations from the normal of the Circle of Willis, polycystic kidneys and coarctation of the aorta Bremer (1943) and Padget (1944) offer a quite different explanation for the congenital origin of some cerebral aneurysms They consider that these diverticula represent the remnants of transitory embryonic vessels which ordinarily become completely obliterated Their arguments are very persuasive and offer a perhaps more cogent reason for the frequency with which aneurysms affect certain arterial sites For instance that part of the internal carotid artery which ultimately becomes intracavernous is the point where the primitive trigeminal artery forms a link with the bilateral longitudinal neural arteries (later to become the basilar artery) This link occasionally persists in adult life as the carotid basilar anastomosis, seen by Harrison and Luttrell (1953) three times in 582 cerebral angiograms and by Sunderland (1948) in three of 210 dissecting room specimens The proximal part of the anterior cerebral artery, and the anterior communicating artery are also sites of recognizable and named embryonic branches which normally disappear These are places where aneurysms are commonly found The finding of bilaterally symmetrically placed aneurysms those which are multilocular and those in infants is more easily explained on this basis (Bassett 1949) Turnbull found an aneurysm in an infant of one year and seven months who had died of broncho pneumonia

An intracranial aneurysm may demand treatment because of the symptoms produced by pressure upon neighbouring structures, or in order to forestall its rupture In the former group are those arising from the carotid artery within the cavernous sinus and those arising above the clinoid processes large enough to compress the optic pathways or the third nerve (Jefferson 1937 1938 1947) Intracavernous aneurysms rarely cause death by bleeding because they are well supported by the dura mater though they may rupture into the sinus and form a carotico cavernous fistula Fusiform aneurysms rarely rupture and those of the basilar commonly cause death by reason of ponto medullary softening The likelihood of eventual rupture in aneurysms other than intracavernous and fusiform is not known but it must be very high and has been estimated at a nine to one probability In Turnbull's necropsy material hæmorrhage was present in two thirds Jefferson (1947) records that of 158 patients with aneurysms approximately one half suffered from hæmorrhage in 40 cases bleeding was associated with a third nerve palsy in 32 cases there was bleeding without local signature in 45 the aneurysm was intracavernous

becomes elongated convoluted and dilated Treatment can only be directed to diminishing the distending effect of the pulse wave within the vessel as by proximal ligature This has been done with success in the case of the internal carotid artery by Hamby, but Ley (1953) considers that carotid occlusion is inadvisable because the lumen of the atheromatous vessel is often narrowed by layers of organized thrombus He recommends the removal of the roof of the optic foramen in order to relieve compression of the optic nerve Fusiform dilatation of the basilar artery is beyond the scope of surgery Saccular or berry aneurysms are the common variety and comprise a lateral diverticulum of the parent artery, but in some cases the sac comes to involve most of the circumference of the main artery and even the nearby branches Jefferson (1952) has drawn attention to this aspect of their anatomy which it is important to recognize, for the sac cannot be excluded from the circulation by a clip or ligature applied to a non existent 'neck Saccular aneurysms have long been regarded as the result of con genital defects in the media (Turnbull, 1915 Forbus 1930) but Glynn (1940) points out that cerebral aneurysms occur only in 0 5 per cent of necropsies although medial defects are so common as to be found in 80 per cent of specimens of cerebral arteries examined and Turnbull found saccular aneurysms of muscular arteries in other parts of the body in only 0 1 per cent of necropsies Glynn also demonstrated by experiments on fresh cerebral arteries that a congenital defect in the muscle if protected by healthy intact elastica can withstand a pressure of 600 mm of mercury Carmichael s studies (1945 1950) lead him to believe that for an aneurysm to develop there must be not only a congenital medial defect or hypoplasia of the muscle of a substantial size, but also a breach of the elastica which is usually the result of atheroma The chance coincidence of both lesions the necessity for the breach to be sufficiently large, and the probability that some small potentially weak places derive protection from atheromatous thickening, explain the discrepancy between the incidence of congenital medial defects and that of aneurysms Atheroma probably accounts for the frequency with which rupture occurs in the older age groups The histological preparations of Carmichael are most instructive, for they illustrate the thinness of the sac wall right up to its con fluence with the parent artery where an abrupt change occurs Although the point of rupture is commonly near the fundus the surgeon has a particular interest in the structure and the fragility of its neck That the ætiology of saccular aneurysms includes a congenital factor is also suggested by the greater incidence of other

should be carried out after an episode of bleeding. Experience has shown that the procedure does not precipitate or aggravate bleeding and work by Bakay and Sweet (1952) has given an explanation for this: injection into the carotid artery as performed in angiography does not raise the pressure within that artery. But angiography carries an extra risk in any patient who is stuporose, probably the added danger of increasing the cerebral anoxia. In practice it is advisable to perform angiography as soon as possible in any patient suspected of having a bleeding aneurysm; the risk of postponing this investigation outweighs any other.

Cerebral aneurysms may be treated by occlusion of a carotid artery or by a direct attack on the aneurysm. Either the internal or the common carotid artery (or both) may be ligated, and the internal carotid artery may be occluded in the neck or within the cranium. Experience has shown that carotid ligation confers a considerable measure of protection against further rupture in many cases, but it may be followed by neurological damage of varying degree and duration. This was shown by Schorstein (1940) to be due generally to anoxic lesions of the brain, and that carotid ligation carries a high mortality rate if performed for a recently ruptured aneurysm. Craniotomy and obliteration of the sac is being more frequently practised in order to avoid these sequelae, as being more likely to give better results in the patient who has recently bled, and because it offers a better chance of permanent cure. It appears the proper choice in cases of bilateral aneurysm.

In order to determine whether carotid ligation can be carried out with safety many surgeons rely on Matas' test. Dandy (1944) stated that in his hands compression of the internal carotid artery for ten minutes without symptoms had never failed to indicate correctly the safety of its ligation. This has not been the experience of all surgeons. Cerebral disturbances have occurred—perhaps the result of a carotid sinus reflex—when subsequently the patient sustained carotid ligation without mishap; conversely the test has had no effect, yet subsequent ligation has been followed by cerebral damage. Digital compression is maintained only with difficulty and, as Sweet has shown, the test can be easily and unwittingly performed inefficiently. A more certain method of applying this test is to expose the carotid and to compress it instrumentally; the surgeon may then proceed to ligation according to the results of the test. Electro-encephalographic abnormalities have been noted to follow the defective circulation consequent upon carotid ligation (Yeager and Walsh 1940; Rogers 1944) but further experience has shown that this promising method is no more reliable than the

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Matas' test Elvidge and Feindel (1950) report a case in which a post ligation hemiplegia was not predicted by the E E G and indeed a relatively normal E E G was recorded during the development of the hemiplegia

In 1948 Sweet and Bennett reported the first of a series of important observations upon the changes in the blood pressure within the internal carotid artery in the neck brought about by its occlusion They found that the intracarotid pressure was reduced on an average to 50 per cent of its original value when the common and the external carotids were simultaneously occluded If only the common carotid was occluded little if any flow occurred from the external carotid into the internal (as has commonly been held to be the case), and in fact a flow might equally well occur from the internal to the external On these grounds and for other reasons they conclude that ligation of the internal carotid artery is less likely to give rise to complications than is that of the common carotid An important observation was that the pulse pressure was reduced to 25 per cent of its original value Thus not only is the tension within the artery diminished but even more diminished is the force of the water hammer effect of the pulse wave *Occlusion of the internal jugular vein had no effect upon intracarotid pressure* Sweet and his co workers have extended these observations (1950 1952 1953) of which the following is a summary The rapid injection of 10 ml of diodrast or saline into the internal carotid artery causes no rise of pressure thus confirming experimentally the clinical evidence that angiography does not precipitate rupture of an aneurysm The fall in pressure which follows carotid compression also occurs in its cerebral branches down to vessels of about 0 4 mm diameter and the percentage fall in these smaller vessels is of the same order as that in the internal carotid artery Although a reduction of pressure to 50 per cent of its original figure was an average finding in some cases the reduction was only to 70 per cent but in others it fell to as low as 30 per cent of its original figure *The value of bilateral cervical sympathetic block* was equivocal because it was found that during the course of a thirty minute observation of carotid occlusion in other patients spontaneous fluctuations of pressure might occur in either direction these fluctuations of pressure provide further support for the view that delayed hemiparesis may be due to progressive anoxic changes rather than thrombosis Cases have been reported however in which thrombosis has spread from the aneurysm into its parent vessel this might more readily occur if the flow of blood in the main stream were more sluggish A few opportunities have

presented to measure the pressure distal to an occluded artery at intervals of from six days to two years after the operation In some the reduction in pressure was nearly as great as at the time of occlusion In 2 the pressure had risen nearly to normal some days after partial occlusion, when total closure of the vessel was not tolerated full closure was then carried out in these patients without sequelæ Measurements of pressure within the vertebral artery and inferior cerebellar artery have been made, and no decrease was registered when the vertebral artery was occluded This gives no support for the treatment of aneurysms of the basilar artery and its branches by vertebral ligation Pressure records have also been reported by Strobos and Mount (1953), who emphasize the importance of maintaining the systemic blood pressure after carotid ligation, neurological sequelæ occurred in 4 out of 14 cases of carotid ligation, and in 3 there was a marked fall in blood pressure Woodhall *et al* (1952) suggest that this technique of recording intracarotid pressures has a part to play in the treatment of drowsy or hemiparetic patients in which carotid ligation is proposed, a reduction of intracarotid pressure by not more than 50 per cent is considered safe, this pressure being obtained by adjusting the tightness of the ligature Johnson (1952) has investigated the effects of carotid ligation by angiography The common carotid artery was first tied and at a later date the internal At the second operation angiograms demonstrated the aneurysm to be smaller by slowly injecting contrast medium into the common carotid artery it was possible to demonstrate that at the bifurcation the blood flow was from the external to the internal carotid artery He concludes that after common carotid ligation the collaterals of the external carotid artery gradually enlarge, and recommends that as a first step the common carotid artery should be ligated, and some weeks later the internal carotid Rogers (1949) considers that the figures derived from his own experience and that of other surgeons show conclusively that ligating the common carotid artery is relatively safe, and he believes that dividing the artery makes it safer but most surgeons prefer ligation in continuity so that the ligature can be removed if hemiplegia develops

In reviewing the results of carotid ligation (1952) Jefferson said A method of treatment stands or falls by its success or failure' Of 250 aneurysms, operation had been carried out in 177, and in 142 cases this comprised ligation of the common or internal arteries or both Death occurred during the first six weeks in 12 and after a longer period in 8 more In 8 it was the same aneurysm that bled, but in only 2 did this occur after the first month 'To have

alive 122 cases, some many years old now, indicates to me that the method is one that has to put it soberly, considerable merit Johnson (1952) points out that in 29 cases the carotid was ligated within a few hours of severe bleeding and it was in these that the 12 deaths occurred, it is possible that lethal damage had already been inflicted by the bleeding Hemiparesis occurred 11 times in a series of 150 cases, and in 7 a permanent serious defect was left (4 6 per cent) Norlen (1952), reporting on the results of 50 carotid ligations found that a hemiparesis occurred in 9 all of which were transitory except 1 The ligature was removed in about half these cases, and in 2 peri arterial sympathectomy had been carried out at the time of the ligation Amongst 31 cases traced for periods of up to fourteen years there were 6 who died of a fresh hæmorrhage in 2 the hæmorrhage came from the same aneurysm, and in 2 probably so in the 5th it came from another aneurysm, and in the 6th its origin is uncertain Poppen (1950) considers that it is safer to ligate the internal than the common carotid and has experienced permanent partial hemiparesis in 4 patients out of ' over 100 ligations of the carotid system Krayenbühl (1946) has given the results of carotid ligation performed in 35 cases of which 20 had bled 6 patients died within two days of the operation and all had been admitted in coma on account of severe fresh bleeding Amongst the survivors there had been no fresh bleeding to date

Obliteration of an aneurysm or its exclusion from the circulation is being attempted with increasing frequency Induced hypotension as an alternative to reducing the pressure within the aneurysm by temporarily obstructing the carotid artery has diminished the technical difficulties which are encountered when an aneurysm ruptures while it is being isolated Without some such aid the torrential flow of blood may prove too great to be removed adequately by suction and with disastrous consequences The first attempt to make a direct attack upon a cerebral aneurysm was made by Jefferson in 1927 although he states he failed to accomplish anything (1947) Dott introduced the method of wrapping muscle around the aneurysm in 1933 and in 1937 McConnell reported that he had opened an aneurysm and packed its cavity with muscle In 1937 Dandy successfully applied a clip across the neck of an aneurysm and later reported that he had been able to do this on four occasions without a death He also introduced the method of trapping aneurysms arising from the internal carotid artery by proximal and distal occlusion of the artery These constitute the basic methods of dealing directly with an aneurysmal

sac The application of a clip or a ligature to the neck or the obliteration of the sac by a series of clips seem the most likely methods to achieve cure and, as Olivecrona has pointed out, one reason for choosing the intracranial method is to attempt an immediate and a permanent cure. Difficulties may be encountered which may not be anticipated by a study of the *angiogram*. A sac may have no neck and may incorporate vessels the importance of which cannot always be assessed. This is particularly likely to be the case with *aneurysms arising from the anterior cerebral and the* anterior communicating arteries. The neck may be present but cannot be approached owing to the relationship to other structures or because it is overlaid by a large sac. The neck may be so friable as to tear when a clip or ligature is applied. Occlusion of the neck necessarily leaves a small segment of the wall of the parent artery weak and we do not yet know whether this will be the site of a further aneurysm. Dissection of the sac may be difficult and fraught with danger on account of adhesions to important structures but if the neck can be isolated and occluded the fundus of the sac—the usual site of rupture—often need not be disturbed. Where the sac cannot be dealt with by these methods then reinforcement by wrapping with muscle should be employed. The whole sac must be isolated so that the material can be packed around it on all sides. The writer (1952) has reported the use of wisps of cotton wool soaked in thorotrast as a method of encouraging the formation of scar tissue which may well in time so stenose the sac as to obliterate it. He has also swathed the cotton wisps or muscle stamps around the parent artery thereby anchoring the aneurysm and perhaps preventing a bulge occurring at its site of origin. If time shows that it will prevent further bleeding reinforcement seems to be the only method available for those sessile aneurysms which involve several important vessels.

In a paper which discusses the various problems in a very lucid and concise manner Norlén and Olivecrona (1953) present their experiences with intracranial operations for aneurysm. Seventy eight craniotomies were carried out, 15 during the acute stage with 8 deaths and 63 during the quiescent period with only 2 deaths. The use of clips rather than a ligature is favoured and only occasionally do they employ reinforcement. In only 3 patients did the operation give rise to any neurological deficits or aggravate pre existing ones. Long term results are not yet available. Falconer (1951) reports 35 cases in which the aneurysm was *subjected to an* intracranial operation in 19 of which a carotid artery had previously been occluded in the neck. There were 5 deaths and residual

disability ascribable to the operation in 4 In 21 patients on whom Mount (1951) performed a craniotomy for a bleeding aneurysm there were 4 deaths 3 of whom had been in coma McConnell Lanigan and Gleadhill (1952) report direct operations on 15 aneurysms without a fatality Records do not yet give long term results of these types of operations although Horrax (1941) stated that he had wrapped an aneurysm with muscle in 6 patients and all had survived for periods of up to six years

In summarizing the surgical treatment of aneurysms it is neces sary to examine clearly the separate clinical problems which these lesions present Some derive from the anatomical site of the aneurysm, some from its size and some from the complicating factor of rupture The development of spontaneous intracranial hæmor rhage brings with it an entirely different set of problems consequent upon the rapidly progressive brain lesion The treatment of such cases must be considered separately and will be discussed last The intracavernous carotid aneurysms form a well defined group in which proximal ligation of a carotid artery in the neck has proved by experience to be the best treatment for those cases which have developed a fistulous communication with the cavernous sinus it may be necessary in addition to clip the internal carotid artery within the cranium Hamby describes an ingenious method first practised by Noland and Taylor by which a portion of muscle is introduced into the internal carotid artery in the neck to form a muscle embolus thereby plugging the fistula The next group consists of supraclinoid aneurysms in which operation is indicated because of pressure upon neighbouring structures or because of pain due to stretching of the sac suggesting imminent rupture In this group may also be included those cases in which the aneurysm has ruptured some time previously and from the effects of which the patient has made a complete recovery in these operation is imperative because there is some evidence that a further rupture is more likely to prove fatal Choice of operation may be made easy by reason of the large size of the aneurysm which precludes any method except carotid ligation A large body of opinion holds that regardless of size carotid ligation is the method of choice for all except those arising from the anterior communicating artery or from vessels above the Circle of Willis Although the reduction of pressure within the carotid holds good for certain vessels above the Circle of Willis it is not clear yet whether a similar reduction of pressure occurs in the anterior communicating artery by analogy from the observation that pressure in the basilar system is not lowered when the vertebral artery is occluded it is likely that

aneurysms of the anterior communicating and anterior cerebral arteries will not be adequately affected unless the communicating vessel is very small or both anterior cerebral arteries are derived from the homolateral carotid. In such the risk of neurological deficit is high though it might be diminished by carotid occlusion in stages. An increasing number of surgeons find that with experience many supraclinoid aneurysms can be dealt with by a local intracranial procedure with a fairly low mortality and morbidity rate and they believe that such operations confer a greater insurance against subsequent rupture than carotid ligation and with less risk of post operative sequelæ.

There remain those cases of recent aneurysmal rupture presenting with spontaneous intracranial hæmorrhage; this group is probably the largest and presents problems of treatment different from and far more difficult than any other. This is not always recognized in the literature as the results of various procedures are assessed irrespective of the stage of the aneurysm in relation to leakage. This greatly confuses the issue and could be compared to an attempt to evaluate different methods of treating, for instance, inguinal hernia irrespective of whether the hernia was strangulated or free (Norlén and Olivecrona 1953). In the acute stage of hæmorrhage the patient suffers immediately from the irritative effect of blood in the cerebrospinal fluid pathways, from the neurological lesions produced by the irruption of the blood into the brain tissue—perhaps imperilling the integrity of the vital vegetative centres; subsequently there develop oedema and softening of brain consequent upon these traumata and upon disturbance of blood supply by occlusion of small vessels by thrombosis and possibly by widespread spasm of the carotid tree. In addition brain function may be progressively impaired by an intracerebral or subdural hæmatoma. The general conduct of the case is similar to that of a severe accidental brain injury—nursing care, attention to shock, avoidance of respiratory obstruction and infection, and adjustment of nutrition, electrolyte and water needs. Surgical treatment will be necessary for the evacuation of a hæmatoma and the frequency of this complication should be more widely recognized outside the neurosurgical centres; where necessary radiological methods should be employed for diagnosis. The treatment of active hæmorrhage is probably never practicable, for if bleeding is too violent to cease (at least temporarily) by natural processes, lethal damage is rapid. Olivecrona and Norlén consider that as a rule it is useless to operate unless the patient survives the first two days. Their figures reveal that the mortality of operations upon patients within the first three

weeks of rupture was approximately 50 per cent, which is similar to that commonly reported for bleeding aneurysms running a natural course In their opinion operation during this period is hazardous because vasospasm may persist for that length of time But against so much delay must be set the observations of Ask Upmark and Ingvar that death may occur in the first twenty four hours or not until the twenty fifth day, but on an average at about the ninth day thus delay beyond the first few days may avoid operation or patients with lethal injuries and delay for several weeks may mean a low operative mortality yet more patients may die who would be saved by operation, and in particular those with a hæmatoma The problem of treatment has been clearly seen and presented by Small Holmes and Connolly (1953) who compare and contrast the results of conservative treatment in 100 consecutive patients with those of surgical treatment in 50 There were 43 deaths in the first group (43 per cent) and 6 in the second (12 per cent) In the latter there was a higher proportion of angiomatous malformations in which hæmorrhage carries a lower death rate than does aneurysm In the conservatively treated cases one third (14) of the deaths occurred within the first twenty four hours only 8 in the next seven days and one third (15) in the following week Intracerebral hæmatomas were found with a similar frequency in each group in about one third of the cases all those patients in whom a clot was evacuated recovered Magee s figures (1943) also suggest that there is a delayed peak in the incidence of death at about the third or fourth week, and cerebral compression by hæmatoma and œdema may well partly account for the delayed deaths If this be so the elective time for operation is probably towards the end of the first week Craniotomy—preceded by angiography and if necessary by ventriculography—is the method of choice so that *clot can be evacuated and a decompression provided, a direct* attack being made on the aneurysm at the same time Some surgeons prefer to ligate the carotid in the neck rather than disturb the aneurysm but the published figures indicate that carotid ligation alone is more likely to do harm than good presumably because dropping the blood pressure within vessels supplying tissue already damaged by trauma and by compression must aggravate anoxia For a similar reason the use of hypotensive drugs during operations on these patients carries a greater risk and the writer considers that the systolic pressure should never be allowed to drop below 80 mm and only for the brief period necessary to deal with the aneurysm the pressure thereafter being immediately restored by posture and by pressor substances

ANGIOMATOUS MALFORMATIONS

Congenital vascular malformations or hamartomas are to be distinguished from the true blood vessel neoplasm, the capillary hæmangioblastoma. There are three main groups, of which the racemose, serpentine or arteriovenous malformations are the most common. These are usually found in the cerebrum. The capillary telangiectasis is rare and usually situated in the brain stem, where it may be a chance necropsy finding or may cause death by rupture; it may be associated with similar skin lesions and may be familial. Cavernous angiomas are also rare; they may be multiple and subcortical or basal in situation, and may be accompanied by similar lesions in other organs. They may give rise to spontaneous intracerebral hæmatomas and suffer destruction in the process, and this could account for a proportion of cases of spontaneous hæmorrhage for which no cause can be found (Margolis *et al.* 1951; Jewesbury 1952). They have been found as the cause of focal epilepsy (Penfield and Ward 1948).

Vascular malformations were at one time regarded as rare lesions and of academic interest only. But a fuller knowledge of their natural history and the increased use of angiography have shown that they are important and not infrequent lesions which may lead to severe disability and death by hæmorrhage. In many cases their surgical removal is a feasible proposition. In Olivecrona's Clinic there were only 18 cases in the period 1923-1935, 42 cases in the period 1936-1946 and 36 from 1947-1950 (Olivecrona 1953). Hæmorrhage occurred in about half of these patients, often causing gross disturbances such as hemiplegia and dysphasia, though recovery took place to some degree. Olivecrona points out that the ultimate outlook in many of these patients is poor. Mackenzie (1953) has recently reported on a series of cases: the first symptom occurred during the second decade in one half and had declared itself by the age of thirty in approximately three quarters. The first symptom was epilepsy in 32 per cent, hæmorrhage (presumptive in some instances) in 30 per cent, and headache in 24 per cent of cases. In approximately half it was thought that an episode of bleeding had taken place, and a cranial bruit was present in one half. Hemiparesis and other neurological deficits which were present in 34 of his 50 patients may not always be due to hæmorrhage, for the development may be gradual and progressive and is then due to the short circuiting of the blood through the malformation depriving the surrounding brain of its nutrition.

Angiographic studies of arteriovenous hamartomas have revealed

that they may occasionally be multiple in the same or different hemispheres, bilateral, and may occur in association with saccular aneurysms of arteries (Moniz and Guerra, 1953) and of veins (Russell and Nevin 1940) They occur most frequently in the territory of the middle cerebral artery It is usually possible to identify one or more enlarged arteries feeding the abnormality, and it may receive blood from more than one of the major groups of cerebral arteries and from both sides The defective supply to the neighbouring brain may also be seen Angiography carried out at an interval after the operative removal of the hamartoma will demonstrate that the abnormal distribution of blood has been remedied (Norlén 1949) Measurements of the cerebral blood flow in these patients have demonstrated a threefold increase in large lesions and it has been estimated that upwards of 1 800 ml of blood per minute may pass through the shunt (Shenkin *et al* 1948) This leads to an increased cardiac output, enlargement of the heart and a low diastolic pressure Repeated angiographic examinations may be necessary by the ordinary methods before successful visualization is achieved and Curtis (1949) and Schurr and Wickbom (1952) using a rapid serial film technique have demonstrated that the inability to reveal a hamartoma by the normal three film method does not necessarily exclude its presence because of the speed of the blood flow through the lesion The opaque medium usually recedes from the hamartoma unduly rapidly in contrast to the delayed emptying of the pathological vessels of a malignant glioma (Wickbom 1948) Because of the risk that the contrast in the lesion may not be caught by the three film method Moniz and Guerra draw attention to certain significant appearances a deeply seated lesion should be suspected when deep veins are filled sufficiently early to be seen with the arteries filling of the sagittal sinus in this phase also suggests an abnormal short circuiting of arterial blood

The forbidding appearances of an angiomatous malformation have led surgeons to assume that it was inoperable Attempts to coagulate the vessels usually provoke their rupture though Trupp and Sachs (1948) claim some success with this method Clips placed upon the main feeding vessels are alone rarely successful, and it is usually not possible to apply them without a deep dissection Like an incomplete removal the lesion is liable to give further trouble The writer has had a case in which post operative angiograms revealed that a small area of predominantly arterial vessels had escaped removal, and the patient subsequently sustained a rapidly fatal hæmorrhage Decompression and deep X irradiation have

rarely given proof of much value. Carotid ligation is liable to be followed by hemiplegia more frequently than when performed for a saccular aneurysm. In 6 patients in which carotid ligation was performed Olivecrona reported that hemiplegia resulted in 4, being permanent in 2. He considers this a dangerous procedure because the short circuiting of blood through the haematoma renders that hemisphere more liable to anoxaemia when it is deprived of a large part of its supply of blood. Krayenbühl and Yaşargil (1958) carried out carotid ligation in 23 patients out of a total of 78. There were no ill effects in 18. In 18 patients in which there had been bleeding carotid ligation was unsuccessful in preventing further haemorrhage in 3. There were 2 deaths, 1 early and 1 late. Of the 21 survivors 13 were fully at work, 4 in part time employment and 4 totally disabled.

The greatest experience of the surgical removal of these lesions has been that of Olivecrona. In his earlier cases extirpation was carried out in only about one quarter, but latterly this proportion has risen to two thirds. Out of a total of 96 cases the lesion was completely removed in 60, with 7 deaths; of the survivors 37 are well and able to work; 6 are total invalids but their disabilities were present before operation. Epilepsy was greatly relieved in many of the cases, particularly in the younger patients. The operation has been rendered less hazardous by the discriminative use of induced hypotension, but nevertheless an ample supply of blood for transfusion should be at hand. The technique of removal may be found in the paper by Olivecrona and Riives (1948).

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